Trombiculid mites infesting birds, reptiles, and arthropods in Malaya, with a taxonomic revision, and descriptions of a new genus, two new subgenera, and six new species

By J. R. Audy

Institute for Medical Research, Kuala Lumpur

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Trombiculid mites infesting bats in Malaya have been dealt with in a previous paper (Audy, 1952). The present paper reviews those species found infesting birds, reptiles, and arthropods collected in Malaya by the Colonial Office (Scrub Typhus) Research Unit, which is now incorporated in the Division of Virus Research and Medical Zoology of the Institute for Medical Research, Kuala Lumpur. These studies, incidental to the investigation of the vectors and potential vectors of scrub typhus, have been supported by grants under the Colonial Development and Welfare Act. This opportunity is taken to clarify some of the relationships between certain groups of reptile-chiggers which are taxonomically very confusing, possibly by convergent evolution in the parasitic larvae. Some important groups are completely unknown in the postlarval stages, and most of the nymphs and adults already known have been insufficiently studied. It is proposed in the present paper to consider the broad genus *Trombicula* Berlese as generally comprising mammal-chiggers, and to separate from it the main groups of related reptile-chiggers.

Notes on Characters of Taxonomic Value

Characters vary in importance among different groups. The following characters have been found important in studying chiggers (larval trombiculids) for the preparation of this paper.

Scutum.—(*a*) The term *'subpentagonal'* is used to refer to scuta where the posterior margin is rounded in the midline and the apex of the pentagon therefore blunt. It appears that groups with such scuta may include members in which the posterior border is crescentic and the scutum not subpentagonal. This usually accompanies broadening of the scutum: the subpentagonal scuta are generally narrower and relatively deeper than the ones with crescentic posterior margins.

(*b*) The *shapes* of different groups of scuta may be very difficult to compare in words but may be compared or contrasted by selecting suitable dimensions and taking ratios. Chiggers with pentagonal or subpentagonal scuta may belong to unrelated groups (e.g. *Neotrombicula*, *Miyatrombicula*, *Blankaartia*), but the pentagonal shape is common among reptile-chiggers broadly related to *Trombicula*.

(*c*) The term *'shoulders'* is used to describe the extension of the scutum in front of the line of the anterior setae. Several different groups show this character. In the subgenera *Trombicula* (especially the *panieri*-group) and *Laurentella* Audy, the margin is sinuous and the shoulders appear hunched. In the *lawrencei*-group and the new subgenus *Eltonella* described below, the anterior margin is almost straight and the shoulders of the scutum slope gently.

(*d*) The *punctation* may require enumeration in the comparison of some species. A convenient measure for this is to count the puncta which lie in the rectangle bounded by the sensillary bases, or in a circle of the diameter of a sensillary base.

Eyes.—The relative sizes of anterior or posterior eyes are conveniently described by comparing their diameters with those of the sensillary bases. Comparisons may then be made without actual measurements. The anterior eye is very large in *T. insolli* Philip & Traub, in the new subgenus *Vercana* described below, and the *lawrencei*-group, and in the latter is a point of distinction from the subgenus *Eltonella* (page 32,). In *Babiangia bulbifera* the posterior eye is considerably larger than the anterior.

Palps.—(*a*) The terms *palpal tarsala* and *terminala** are proposed to describe the blunt basal 'spur' and the apical 'seta' which is usually pointed. Both these are true solenidia (hollow, refractile; striated or not), and the terminala must not be confused with a simple nude seta. The terminala may be absent, as in the subgenus *Euschöngastoides*. In *Eutrombicula (Eltonella) eltoni* n.sp. the palpal tarsala is nearly as long as the claw; both tarsala and terminala are very long in *Siseca subrara* n.g., n.sp., described below. In the course of the present study, the writer noted that a terminala appears to be present on the palpal tarsus of reptile-chiggers generally (*Babiangia, Eutrombicula* except for *Eltonella* ?, *Fonsecia, Schongastia, Siseca*) and on the bird-chiggers *Blankaartia* and *Heauslipia* and *Neoschongastia*, as well as on the mammal-chiggers *Neotrombicula* which however are closely related to *Blankaartia*. The terminala is absent in the bird-chiggers of the new subgenus *Vercana* described below and it is present in certain true mammal-chiggers such as the subgenus *Walchiella* and the *similis*-group.

(*b*) The *setation of the palpal tarsus* is important and may be added to complete the palpal formula (Audy 1952:145), using B and N to indicate barbed and nude setae as Vercammen-Grandjean has done in his recent descriptions of African chiggers. The enumeration of these setae is a necessary part of the description of a chigger: the differences between the six palpal tarsi figured in the present paper are notable.

(*c*) The *general development of the palpal setae* appears to be a group character. In both the *lawrencei*-group and *Eltonella* these setae, especially the femoral and genual, are poorly developed, and they may be nude or ciliated or lightly barbed. The same applies to *Laurentella* and *panieri*-group (subgenus *Trombicula*). In such conditions the palpal formula may not be particularly important. In other groups the setae are strongly developed, in which case the palpal formula may be an important group character: an example is the subgenus *Vercana*.

Legs: measurement of tarsi.—*Lengths of the legs* are usually given in descriptions, but these measurements cannot always be made or compared accurately because the legs may be bent and the joints may be stretched or otherwise on mounting. Also, these measurements are useless for most comparative ratios. The lengths of the tarsi

* *Note in press.*—When writing this, I overlooked the fact that Wharton & Fuller (1952:32, 38, fig. 13A) have named the palpal 'terminala' a *subterminala*, which is a better name because this seta is usually subterminal and not terminal in position. This name implies homology with the subterminala of Leg I, which is likely to be correct. In figs. 4, 6, 8, 10 of the present paper, the subterminala of the palps is shown as striated: this is not because the striae (if present) can readily be seen, but to indicate that this is a specialized hollow sensory seta of the same kind as the tarsala and is not to be confused with nude ordinary setae such as may be found, for example, on some species of *Euschöngastia*, subgenus *Laurentella*. In figs. 2 and 3 of the present paper, a nude seta has been shown without striae; as explained in the text, these setae *appear* to be ordinary nude setae and not true subterminalae, but this should be checked with fresh material and better specimens. *Subterminala* should be substituted for the palpal *terminala* in the new descriptions in the present text.

plus pretarsi can however be measured accurately, are of taxonomic interest, and are usable. If in addition the maximum widths of tarsus I and tarsus III are measured, further useful ratios become available: for example, the ratio length/width for tarsus III varies from 1·5 in an undescribed intranasal species of *Laurentella* to over 6 in *Neoschöngastia mirafra*. In the *lawrencei*-group, there appears to be a series ranging from typical species with subpentagonal scuta and a long tarsala II with bulbous tip, through intermediate forms to species without subpentagonal scuta and a normal but cylindrical tarsala II. The tarsus (plus pretarsus) III tends to shorten and the SBs to separate along this series, so that the ratio T3/SB ranges from 2·3 to 3·3 in the first group and 1·6 to 2·3 in the second group, the intermediate species having intermediate ratios.

Chaetotaxy of Legs.—The credit for recognizing the taxonomic importance of the specialized leg-setae in the case of larval trombiculids apparently belongs to Fonseca (1932), while Wharton (1947, 1948) systematized descriptions by introducing names for these setae.

(*a*) The *tarsalae of legs I and II* often repay measurement and detailed comparisons with each other and with the lengths of their respective tarsi (see Brennan 1951, 1952, &c; Brennan & Jones, 1954). Tarsala-I is exceptionally long in the subgenus *Eltonella* and in *Endotrombicula* Ewing, and is a distinguishing feature of *T. (Leptotrombidium) tarsala* Traub & Audy, 1954. Tarsala-II is obviously longer than tarsala-I, and also modified, in typical members of the *lawrencei*-group and in *Sauriscus* Lawr.

(*b*) The *relative positions* of tarsalae and microtarsalae are important. In the subgenera *Trombicula* and *Neotrombicula* Hirst the microtarsala-I is anteroproximal and close to the base of the tarsala; in the *flagellifera*-group and in most of the reptile-chiggers considered in the present paper it is distal to and separated from the tarsala. In *Walchiella* Fuller, the *Euschöngastia lacunosa* group, and the Gahrliepiines, the microtarsala-I is posteroproximal and not adjacent to the tarsala; in *Laurentella* it may be proximal or distal. A characteristic of *Helenicula* Audy is the placing of tarsala and microtarsala subterminally: the tibialae and microtibiala are likewise placed together on the distal edge of the joint.

(*c*) The *anterior (distal) tibiala* of leg I, and often leg II, may be blunt and short, even rivalling the tarsala in size and shape, while the posterior (proximal) tibiala remains pointed, longer, and more slender. This difference is found in many chiggers, but it is very obvious in some member of the *lawrencei*-group, in *Eltonella*, *Fonsecia*, *Babiangia*, and especially in *Sauriscus*. In these groups, the arrangement of these setae on leg I is the stouter and more blunt tibiala anterodorsal and distally placed with the microtibiala immediately posterior to it, and the second more pointed and slender tibiala proximal and posterior to the microtibiala. In *Sauriscus* the microtibiala I is so elongated as to resemble a tibiala. In *Leptotrombidium* and *Gahrliepiines* for example the blunt distal tibiala is posterior and not anterior to the microtibiala, and the exact arrangement of these three setae varies considerably between or within different groups.

(*d*) The *genualae of leg I* may number 3, 2, or exceptionally none and the differences in number and arrangement are taxonomically important. In one generic group (*Gahrliepia*, *Guntherana*, *Schouteden ichia*, and *Doloisia*) the presence of 2 instead of 3 genualae-I appears to be regularly correlated with the absence of tibiala-III and this is a significant feature: this association was found independently and simultaneously by P. H. Vercammen-Grandjean in the Congo. In other groups, the features concerned are variable and the association is not significant except at the level of the species, as shown

by Brennan & Jones (1954) for species of *Euschöngastia*. Among the chiggers related to *Trombicula*, 2 genualae-I appear on most of the mammal chiggers such as *Leptotrombidium*, *Neotrombicula*, members of subgenera *Trombicula* (e.g. *insolli*) and *Vorcana*, and the *leveri*- and *flagellifera*-groups. Most of the reptile-chiggers, however, have 3 genualae-I (*Eutrombicula* s.lat., *Fonsecia*, *Babiangia*, and *Sixeca*; also *Blankaartia* and *Heaslipia* which appear to favour water-birds); and so also do *Speleocola* Lipovsky and some other member of subgenus *Trombicula* (e.g. *harrisoni*-group), which usually parasitize bats.

(*e*) *Nude setae* on the legs refer to ordinary setae without barbs and not to the specialized solenidia which are nude by nature and have a characteristic structure: the solenidia are named after the leg-segments in accordance with the names introduced by Wharton. The whiplike nude setae, which are not solenidia, are also named after the leg-segments but with the prefix *masti*-. Two types of ordinary nude setae should be recognized, for in some groups (e.g. *Laurentella* and *panieri*-group) the setae on legs (including coxae) and palps are not strongly developed, being only delicately barbed or ciliated. The appearance of nude setae among some species in such groups is not particularly significant except at the level of the species. In other groups, however, nude setae appear among well developed and strongly barbed setae, and these nude setae are more characteristic of groups than of species. Moreover, such setae are often long and outstanding, and occur in special situations. Wharton's intention was clearly to refer to such setae as mastitarsalae, mastitibialae, etc. Two points must be noted in connexion with these. First, one must be prepared at any time to find a species in which a group-characteristic masti-seta bears some barbs (often near the base). In such a case, this seta can be seen on close examination to differ from its neighbours. It may be referred to as, e.g., a 'mastitarsala-III with a few small barbs': for example, *E. montensis* Lawr. may have a small barb or ciliation on the mastitarsala-III which is characteristic of the group (*lawrencei*-group). Second, such masti-setae appear to have arisen independently in many unrelated groups and their significance must be interpreted with caution. The mastitarsala-III in *Eutrombicula* s.str., is fairly strongly developed and situated midway along the tarsus or in the proximal half. In the *lawrencei*-group, the mastitarsala-III is very fine and tapering and is situated on the distal half or distal third of the tarsus: it resembles curiously the mastitarsala-III of many African species of *Euschöngastia*.

Descriptions of Six New Species, with a New Genus and Two New Subgenera

The taxonomic relationships of the following new species and groups are discussed later together with other records of Malayan chiggers parasitizing birds, reptiles, and arthropods. *Eutrombicula* is here treated as a genus instead of as a subgenus of *Trombicula* and it is divided into three subgenera (two here named) and a species-group. A new subgenus, *Vorcana*, is raised for the *Trombicula vorca* species-group, but no new species is described in it. The genus *Babiangia* Southcott is considered in a broad sense on page 46.

The authorities for the names of the hosts of the new species are the lists in Smith (1935) and Tweedie (1953), as noted on p. 65 below. Identification of the hosts has been the responsibility of J. L. Harrison, Zoologist, Institute for Medical Research. Numbers prefixed by CORU. (for Colonial Office Research Unit) refer to slides (specimens), and those prefixed by R. to hosts, in the registers of the Division of Virus Research and Medical Zoology.

Genus **Eutrombicula** Ewing, 1938, sensu lato, revised

Type.—Microthrombidium alfreddugèsi Oudemans, 1910.

Diagnosis (revised).—Trombiculinids of which the larvae have the usual five scutal setae and unexpanded barbed sensillae; scutum pentagonal, subpentagonal, or with posterior border crescentic, and the anterior border extended in front of anterior setae (i.e. with anterolateral shoulders); usually with at least one mastitarsala-III, may be with mastitibialae-III; leg I with three genualae; larvae parasitic on reptiles but in a few cases also attacking birds and mammals (in one case confined to an arthropod). Nymphs and adults figure-8-shaped with subtriangular sensillary area and usually with single eyes placed close to sensillary bases.

Subgenus **Eutrombicula** Ewing, 1938

Type.—Microthrombidium alfreddugèsi Oudemans.

Diagnosis.—Larvae with 2-pronged palpal claw, the smaller accessory prong being ventral or internal to the axial prong. Scutum only exceptionally subpentagonal. Tarsalae subconical, not elongated, that on leg II shorter than tarsala-I. A New World and Australasian subgenus extending to some extent into the Oriental region. [This is *Eutrombicula* of Ewing and is the same as the subgenus *Eutrombicula* (genus *Trombicula*) of Wharton & Fuller 1952, but excluding the species *T. mauriquei* Ewing, which is known only from the adult, and *T. minutissimum* (Ouds.) which is very closely related to the *Trombicula (Trombicula) panieri* group].

Species in Oriental & Australasian regions.—This subgenus is typically represented in these regions by *E. (E.) wichmanni* (Oudemans). In addition to the species listed by Wharton & Fuller under subgenus *Eutrombicula* we may add:—

Eutrombicula (Eutrombicula) ablephara (Womersley), new combination
— *Trombicula ablephara* Womersley, 1952:86.

Eutrombicula (Eutrombicula) tovelli (Womersley), new combination
— *Trombicula (?Neotrombicula) tovelli* Womersley, 1952:116.

New Subgenus (**T. lawrencei**-group), Audy & Vercammen-Grandjean in MS.

Representative species.—Trombicula (Trombicula) lawrencei Wharton & Fuller 1952:67, *nom. nov.* for *Eutrombicula agamae* Lawrence, 1949 (not *Trombicula agamae* Andrè).

Diagnosis.—Larvae with 3-pronged (exceptionally 2-pronged) palpal claw, an accessory prong being external; scutum frequently subpentagonal; tarsala-II narrow and cylindrical (not subconical like tarsala-I) and either subequal to or exceeding tarsala-I

in length; tip of tarsala-II blunt, usually expanded, frequently bulbous. Nymphs and adults unknown. So far recorded only from reptiles of the Ethiopian region. [This is the *Trombicula lawrencei* group plus the *T. ilesi* group of Audy 1954:148, less the species *T. ilesi* Radford itself, which is distinct and is being redescribed].

Comments.—Lawrence (1949) placed a number of species in the genus *Eutrombicula* although this was at variance with his key to genera (his p.469), for most of these species had 3-pronged palpal claws. Two related species *(nivaria, rhodesiana)* were placed in the genus *Trombicula*. Wharton & Fuller dealt with *Eutrombicula* in its restricted sense, as a subgenus of *Trombicula* for reasons which they state, and they therefore were obliged to relegate Lawrence's species to their heterogeneous subgenus *Trombicula*. In the light of later studies, Audy 1954:147 proposed that the subgenus *Trombicula* be restricted, leaving a number of chiggers of uncertain status which could then profitably be broken up into species-groups without assigning them to a subgenus until their status was clear. Lawrence's species were accordingly placed tentatively in two groups, an *ilesi*-group (pentagonal scuta) and a *lawrencei*-group (posterior margin crescentic), but the chiggers themselves had not been examined. These species have since been studied by the writer and the results are to be published in the Annals of the Natal Museum in collaboration with P. H. Vercammen-Grandjean. The *ilesi*-group must at present be considered monotypic, containing the distinct species *T. ilesi* Rad. All the other species (*aenigma, draconensis, gerrhosauri, homopholis, lawrencei — agamae* Lawr., *microps, montensis, nivaria, pachydactyli, rhodesiensis*, and *rhoptropi*) form one group which is here referred to as the *lawrencei*-group, sensu lato, and is being made a subgenus of *Eutrombicula*, sensu lato, in the paper referred to. A most distinctive feature is the peculiar development of tarsala-II (see fig. 5), and a re-examination of *Sauriscus ewingi* Lawr. shows that it has developed from this group and has further modifications of the specialized leg-setae. The *lawrencei*-group is linked to *Eutrombicula* by the new *fieldi*-group (below). The posterior margin of the scutum ranges from bluntly angulated (scutum subpentagonal) to deeply crescentic, the latter being associated with generally broader scuta with wider separation of sensillary bases, the ratio tarsus-III/SB ranging from 2·3 to 3·3 in the 'pentagonal' group and 1·6 to 2·3 in the 'crescentic' group. The scuta of the 'crescentic' group (e.g. *gerrhosauri*) cannot be distinguished from those of the *fieldi*-group. The palpal formula is variable, usually b.b.(N).NNb, setae on femur and genu being poorly developed (the palpal formula for the *fieldi*-group is N.N.NNN). The mastitarsala-III is present, fine and tapering, on the distal half of the tarsus. Unfortunately not a single nymph is known for this large group. Judging by larval characters alone, it would seem that the *lawrencei-*, *fieldi-* and *ilesi*-groups are congeneric with *Eutrombicula* but not with *Trombicula*.

Eltonella, New Subgenus

Type.—Eutrombicula (Eltonella) eltoni n.sp.

Diagnosis.—Larvae with 3-pronged palpal claw, an accessory prong being external; scutum sharply pentagonal and fairly small; eyes reduced or rudimentary (anterior eye subequal to or smaller than a sensillary base—the anterior eye is ×2 or more diameter

of a sensillary base in the other subgenera); tarsala-I elongate, tarsala-II relatively short and without terminal expansion. Nymphs (known only for *E. eltoni*) with eyes close to sensillary area, sensillae with slight swelling of shaft and profusely barbed; tarsus of leg I tapering. So far recorded only from Oriental and Australasian regions, one species being parasitic on an arthropod (scorpion).

Eutrombicula (Eltonella) eltoni n.sp. (figs. 1 & 2)

"Trombicula (Tragardhula?) sp. indet.", Audy, 1950.

Trombicula (Trombicula) frittsi Wharton, Womersley, 1952:128, 330.

Trombicula (*?ilesi*-group) *frittsi*, Audy, 1954:146,148.

Diagnosis of Larva.—The diagnosis of the three members of this group from each other is given in the table below.

Redescription of Larva.—Body very small; partially engorged larvae 230 × 180$_{\mu}$; subovate, pallid. *Gnathosome:* chelicerae blade (24$_{\mu}$) fairly broad, with one subapical and one dorsal denticle and a small nubbin on the external aspect, presumably derived like the subapical denticle from a development of the usual tricuspid cap. Galeal seta N. Palpal formula b,b,bbB, setae not strongly developed, with one or a few delicate ciliations or barbs, femoral and genual setae shorter than the tibial and inconspicuous, may appear nude; palpal tarsus with 5 barbed setae (two being with few barbs), and one nude or scantily barbed seta, terminala absent, basal tarsala cylindrical and long (nearly as long a claw); claw (15$_{\mu}$) 3-pronged, accessory prongs ventral and dorso-external to axial prong. Scutum pentagonal, PW obviously greatly than AW, anterior margin almost straight and with shoulders, posterior margin acuminate with very few overlapping cuticular folds near the apex, lateral margins straight; punctae fairly numerous (about 30 between SBs), extending over almost whole surface. Scutal and dorsal setae subequal and similar, with inconspicuous barbules along the shafts; AM anterior to line of ALs. Sensillary bases posterior to line of the PLs and closer together than half the AW. Sensillae with 5–9 well-spaced long barbs placed alternately on distal half of shaft.

Comparison of Species, subgenus *Eltonella* n.subg.

	Eutrombicula eltoni n.sp.	*Eutrombicula swerdlei* n.sp.	*Eutrombicula frittsi* (Wharton)
Hosts	Scorpion, Malaya	Lizards, Malaya	Lizards and rats, S.W. Pacific
Colour	pale yellowish	orange	red
Eyes (in old mounts)	indistinct or invisible	indistinct	distinct
Scutal puncta ..	small and numerous (30*) evenly distributed over whole scutum	large and sparse (5–10*), fewest near AM	large and sparse (10–15$_{\mu}$), fewest near AM
Posterior angle ..	not markedly wrinkled	markedly wrinkled	markedly wrinkled
Sensillae	5–7 long distal barbs, open-spaced	10–12 closely placed barbs	stout short shaft, closely placed barbs.
Palpal setae ..	inconspicuous, very fine ciliations	stouter but with few barbs	barbs well developed.
Mastitarsala III ..	absent	present	present

* Number of punctа in rectangle between sensillary bases.

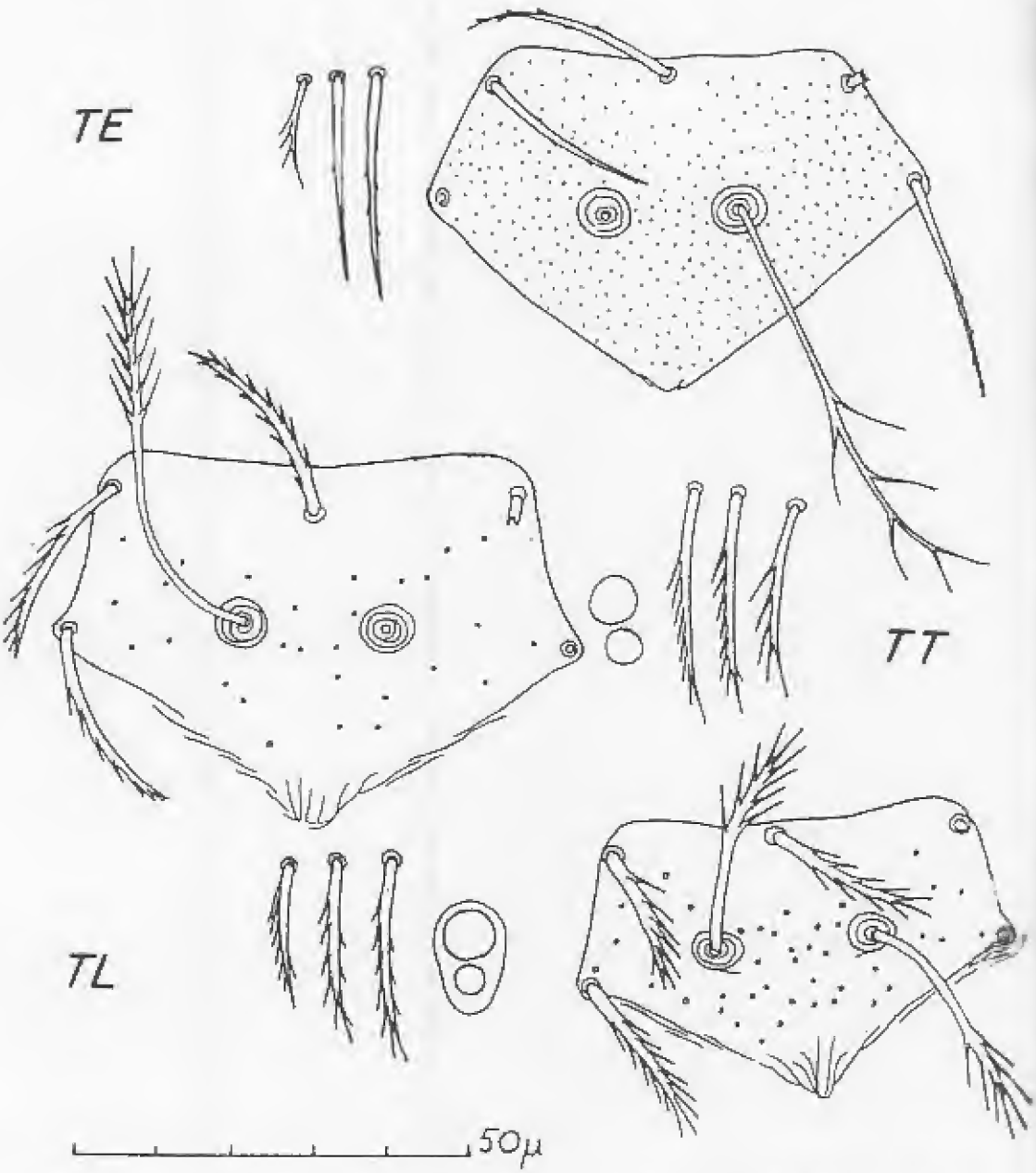

Fig. 1. Subgenus *Eltonella*: scuta, eyes, and body setae (humeral, dorsal, and ventral). *TE*—*Eutrombicula (Eltonella) eltoni* n.sp. *TT*—*Eutrombicula (Eltonella) tweediei* n.sp. *TL*—*Eutrombicula (Eltonella) frittsi* (Wharton). (See also Figs. 2 & 3).

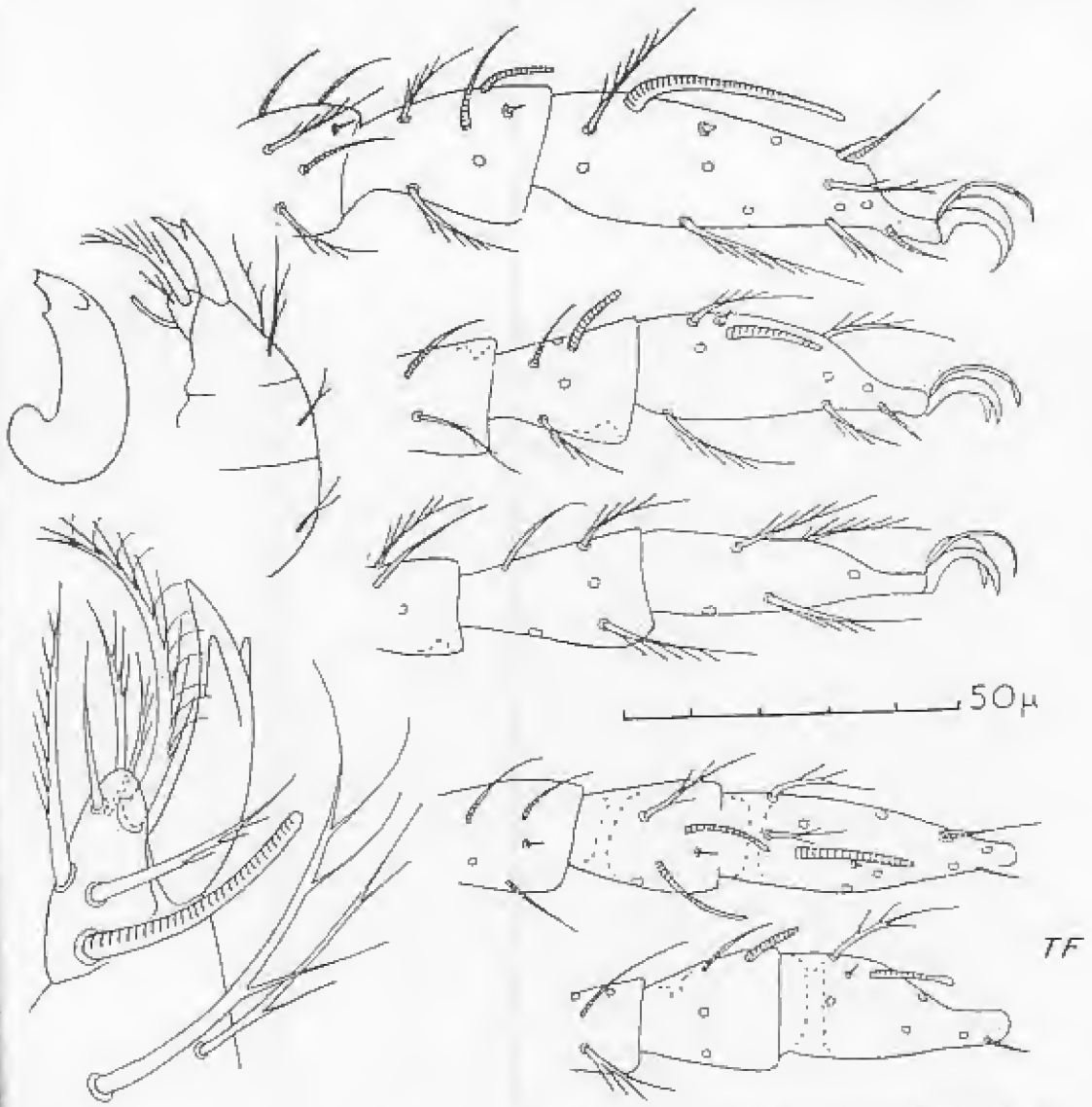

Fig. 2. *Entrombicula (Eltonella) eltoni* n.sp.: details of gnathosome and chaetotaxy of legs I, II, & III. *TF—Entrombicula (Eltonella) frittsi* (Wharton): details of chaetotaxy of legs I & II for comparison.

STANDARD MEASUREMENTS IN MICRONS, *E. eltoni* n.sp. (Holotype, 3 Paratypes, and 7 larval pelts) as recorded by Womersley, 1952:129.

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AM*	*AL*	*PL*	*Sens*
Mean of 11	47·6	63·1	17·4	20·1	22·4	17·3	31·1	25·8	32·3	50·4
s.d. ..	1·25	3·15	1·29	1·69	0·00	1·14	1·69	2·21	1·46	0·00

Legs: All 7-segmented, tarsus III shorter than tarsus I, tarsala-I elongate, ordinary setae barbed or pectinate with tips of shafts free and tapering, without irregular variations in length. Leg I: tarsus plus pretarsus 58 × 18μ, tarsala (34μ) reaching to subterminala, with

microtarsala distal to its base less than midway along its length, subterminala shorter than tarsala, parasubterminala, pretarsala, and 16 barbed setae; 2 tibialae, anterior cylindrical blunt and posterior pointed and longer, microtibiala, and 6 barbed setae; 3 genualae, two being anterior in tandem, microgenuala posterior to one genuala, 4 barbed setae with few barbs; telofemur with 5 barbed setae; basifemur, trochanter, and coxa each with one barbed seta. Leg II: tarsus and pretarsus 44μ; tarsala 18μ, blunt microtarsala antero-proximal and close to its base, pretarsala, 16 barbed setae; 2 tibialae in tandem, distal tibiala conspicuously longer and stouter than proximal and subcylindrical, 5 barbed setae; 1 genuala, 2 barbed setae; remaining segments with 1 barbed seta each. Leg III: tarsus plus pretarsus 51 × 14μ, 14 barbed setae on tarsus, one proximo-dorsal seta carrying fewer (3–5) barbs than the others but no longer or outstanding; tibiala, 6 barbed setae; genuala longer than genu, 4 barbed setae; femora, trochanter, coxa with one barbed seta each. *Body setae.*—Dorsal setae similar to PLs but slightly shorter, arranged 2.6.6.4.2.2. = 22 DS (28μ, HS 32μ) + 4 caudal setae (CS, 22μ) + 12–14 VS (15μ), distinguished from caudal setae by their length and longer barbules.

Type Material.—Holotype CORU. 8667 and 6 Paratypes from R.7971, *Heterometrus longimanus* (Herbst) (Giant Black Scorpion of Burma and Malaysia) Bukit Lagong Forest Reserve, Kepong, Selangor, 21.ix.1949. Eleven nymphs have been reared and their correlated larval pelts preserved. Holotype (BM. 1956.8.21.1) and a Paratype deposited in the British Museum (Natural History), Paratypes in the U.S. National Museum, S. Australian Museum, and the author's collection.

Comments.—This species was confused with *T. frittsi* Wharton (fig. 1) and added to the re-description of that species by Womersley (1952). In the redescription, *frittsi* is described as without a mastitarsala III, and Wharton is quoted as if stating that tarsus III has a rod-like sensory seta (i.e. a tarsala); there is also some confusion between tibia and tarsus. Wharton's description reads "One sensory seta on each tarsus. Tibia III with a sensory seta", but his figure, drawn before the nature of these various special setae had been worked out by him, is admittedly misleading. His statement is however correct: *frittsi* has a tibiala-III and a mastitarsala-III, and the legs resemble those of *tweediei*. This comparison has been made, and the scutum in fig. 1 drawn, from specimens kindly sent to the writer by Dr. Wharton: two of these specimens came from the footpads of a gecko from Samar (20.ii.1945, *Carver, NAMRU 2*) and one from the footpad of a gecko, *Gehyra oceanica*, Bougainville (2.ix.1944, *NAMRU 2*). It is noteworthy that *E. frittsi* was also recorded from *Rattus praetor*: the two related Malayan species have not been found by us on mammals.

The nymph of *E. eltoni* has been described by Womersley (1952:330, figs. 87D–G) under the name of *T. frittsi*. No further studies have been made. The presence of para-sensillary eyes suggests that this species should be compared carefully with *Eutrombicula* s.str.

This species* is named for Charles Elton, F.R.S., to whom ecologists and epidemiologists must be grateful for ideas and guiding principles in the sphere of animal ecology, and to whom the present writer is indebted in many ways, not the least being the example set of lucidity in writing on ecological subjects without a trace of the jargon and monstrous Greek derivatives which have ministered by cryptology and neologism to an esoteric obfuscation of ecological neoconcepts.

Eutrombicula (Eltonella) tweediei n.sp. (figs. 1 & 3)

Diagnosis of Larva.—Diagnosed from *frittsi* and *eltoni* as shown in the table, p. 33.

Description of Larva.—*Body* small, partially engorged larvae 230 × 170μ: elongate, subovate, colour orange to bright orange. Eyes 2 + 2, anterior eye distinctly more chitinized than posterior. *Gnathosoma:* Chelicer similar to that of *eltoni*. Palpal formula B,b,NNB, with the setae generally stouter than those of *eltoni*; palpal tarsus with tarsala not unusually long.

* In accordance with normal ethical procedure, this species would be named for Womersley but this has not been done because there is a risk of confusion with a species of *Trombicula* so named in MS by another author.

Fig. 3. *Eutrombicula (Eltonella) tweedlei* n.sp., details of gnathosome and chaetotaxy of legs I, II, III. One palpal claw of one specimen had 4 prongs (duplication of ventral accessory prong).

and 5 barbed setae of which one (posterior) is stout and distally plumose and two internal ones which have few barbs and may appear nude; plus a subapical nude seta which does not appear to be refractile. Claw similar to that of *eltoni* but with the ventral accessory prong curving inwards (in one specimen, the ventral prong is duplicated, see fig. 3). The setae on the fused coxae of the gnathobase have only a few (*ca.5*) branches. *Scutum:* anterior portion, in front of PLs, larger than corresponding portion of *eltoni*, the relative positions of PLs and AM being about the same but the ALs being displaced about the diameter of the SBs forwards and sideways, AM thus lying slightly behind line of ALs. Anterior border slightly concave, AL shoulders present; posterior border similar to that of *eltoni* but apex more pointed, cuticular striae overlapping the border, the apical striae present on the scutum similar to those indicated by Wharton for *fritsi*. Puncta very sparse (about 5 between SBs), not extending to anterior margin. Standard measurements as shown below. *Legs:* tarsus III slightly longer than tarsus I, ordinary leg setae generally less developed than with *eltoni* but with fairly long barbs, mastitarsala III present, micro-setae generally long.

STANDARD MEASUREMENTS IN MICRONS, *E. tweedii* n.sp. (Holotype & 6 Paratypes)

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AM*	*AL*	*PL*	*Sens*
Holotype ..	47	59	17	18	24	22	24	23	26	45
Mean of 7	47·9	58·8	16·5	17·1	23·6	19·2	25·9	22·1	26·1	47·1
s.d. ..	1·20	2·63	0·88	0·59	1·72	2·07	1·80	1·26	1·39	2·88

Leg I: tarsus plus pretarsus 45 × 22μ, tarsala (24μ) extending beyond base of subterminata, microtarsala long, distal from tarsala about 1/3 along its length, subterminala well developed, parasubterminala, pretarsala, and 17 barbed setae; 2 subequal pointed tibialae, elongated microtibiala, 7 barbed setae; 3 tapering genualae, elongated microgenuala, 4 barbed setae: telofemur with 5, basifemur, trochanta and coxa with 1 barbed seta each. Leg II: tarsus plus pretarsus 42μ, tarsala (17μ) cylindrical, microtarsala not elongated, pretarsala, 16 barbed setae; 2 tibialae, the distal blunt and as thick as the tarsala, the proximal tibiala longer and pointed, 6 barbed setae; long genuala, 3 barbed setae; remaining segments and coxa with 3, 2, 1, 1, barbed setae respectively. Leg III: tarsus plus pretarsus 50 × 17μ, long tapering mastitarsala present on proximal half of tarsus, and 13 barbed setae; long tapering tibiala, 3 barbed setae; long genuala, 3 barbed setae; remaining segments and coxa with 3, 2 and 1 barbed setae, the posterodorsal seta on the basifemur being ciliated or nude. *Body* setae: 2.6.6.4.2.2. = 22 DS (24μ, HS 26μ) + 4·2 = 8 CS (23μ) 4·4·2 = 10 VS (22μ) the VS being comparatively longer than in *eltoni* and not differing much from the CS.

Type Material.—Holotype, CORU.40789, & 19 Paratypes ex R37615 *Draco fimbriatus* (flying lizard), Bukit Lagong F.R., Kepong, Selangor, 13.viii.1954; 1 Paratype ex R39502 *Draco volans* (Common Flying Lizard), Ulu Langat F.R., Selangor, 12.ii.1955. Holotype (BM.1956.8.21.3) and Paratypes deposited in the British Museum (Natural History). Paratypes in the U.S. National Museum, Rocky Mountain Laboratory, S. Australian Museum, Queensland Institute for Medical Research, Natal Museum, Zoological Survey of India, and collections of various acarologists.

Comments.—The species is named for M. W. F. Tweedie, Director of the Raffles Museum, who is an authority on Malaysian reptiles and to whom we are grateful for much advice and collaboration.

Eutrombicula fieldi species-group, new group

Representative species.—Eutrombicula fieldi n.sp.

Diagnosis.—Differs from subgenus *Eutrombicula* in having accessory prong of the 2-pronged claw external instead of internal, and scutum with generally less developed punctation and with anterior margin almost straight, not sinuous. Differs from the African *lawrencei*-group (above) in having 2 (not 3) prongs to palpal claw and a normal subconical and relatively short tarsala II. Differs from *Eltonella* in the size and shape of the scutum, 2-pronged palpal claw, and well-developed eyes. Nymphs unknown. Larvae apparently confined to reptiles, so far recorded only from the Oriental and Australasian regions.

Species included in fieldi-*group.*—

Eutrombicula (*fieldi*-group) *fieldi* n.sp. from lizards, Malaya.

Eutrombicula (*fieldi*-group) *lygosomoides* (Womersley), new combination

= *Trombicula lygosomoides* Womersley, 1952:100, from a lizard, New Guinea.

Eutrombicula fieldi n.sp. (figs. 4 & 5)

Diagnosis of Larva.—Most closely resembles *E. lygosomoides* (Wom.), which has a much larger scutum, a mastitarsala III, and striate-punctate coxae and gnathobase. Differs from *E. ablephara* (Wom.) in having an external instead of ventrointernal accessory palpal claw and no mastitarsala III.

Description of Larva.—Body when partly engorged 370–420μ × 250–300μ, elongate oval. Colour light orange to orange. Eyes 2 + 2 on ocular plate, anterior eye chitinized and over 1·5 times diameter of SB. *Gnathosome:* Cheliceral blade broad (29 × 8μ) with a small dorsoapical and small ventral tooth. Palpal formula N.N.NNN, setae on femur and genu shorter than the others, ventral tibial longest, all setae tapering; basal tarsala less than half length of claw, apical terminala pointed, and 5 barbed setae. Claw 2-pronged, axial prong (15μ) curved near tip, dorso-external accessory prong almost straight, distinct. Galeal seta N. *Scutum:* with relatively few coarse punctae (about 10 in rectangle bounded by SBs), anterior margin advanced anterior to setae, with evenly rounded AL shoulders but otherwise almost straight; posterior margin evenly convex, ASB and PSB subequal; cuticular striae encroach slightly on the posterior margin and may give an appearance of slight flattening in the midline; SBs fairly wide apart, nearly equal to AL-AW interval (half AW), situated midway between ALs and PLs; AL setae shortest, PLs longest, all setae with fairly stout blunt shafts and inconspicuous barbs (or bases of barbs) giving a serrated appearance. Sensillae intermediate in length between SB and AW, with 5–6 barbs in distal half. Standard measurements as shown below, together with data for *lygosomoides*.

STANDARD MEASUREMENTS IN MICRONS, *Eutrombicula fieldi* n.sp. (Holotype and 6 Paratypes) and *E. lygosomoides* (Wom.)

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AM*	*AL*	*PL*	*Sens*
Holotype, *E. fieldi* ..	66	74	29	22	22	21	26	23	38	43
Mean of 7	65·4	73·8	30·3	29·2	24·5	21·1	27·6	23·3	36·2	44·3
s.d. ..	1·71	1·43	1·06	1·13	1·38	0·68	0·73	0·93	3·14	9·43
E. lygosomoides Mean of 7 (after Womersley)	102·7	123·4	47·6	29·0	37·1	33·9	38·3	47·7	53·1	64·0

Legs: 7-segmented. Coxae 1-setose. Ordinary setae barbed or pectinate, subequal except for the longer setae on trochanters and basifemora of legs I and II. Sensory and other setae as follows: Legs I: tarsus plus pretarsus 62 × 23μ, tarsala stout, 17μ, microtarsala distal to its base and about halfway along its length, subterminala subequal to tarsala, parasubterminala, pretarsala prominent, and 21 barbed setae; 2 tibialae, subequal, not stout, one posteroproximal to the other with microtibiala distal to its base, 8 barbed setae; 3 genualae, two being in tandem, 4 barbed setae; remaining segments with 5, 1, 1, barbed setae. Leg II: tarsus plus pretarsus 48μ, tarsala 15μ, somewhat pointed, microtarsala long and proximal to its base, pretarsala, 15 barbed setae; 2 subequal tibialae in tandem, distal one with blunt tip, 7 barbed setae; 1 genualae, 3 barbed setae; telofemur, 4 barbed setae; basifemur with long (40μ) posterior and fairly long anterior barbed setae; trochanter with long anterior barbed seta. Leg III: tarsus plus pretarsus 60 × 18μ, 15 barbed setae, without mastitarsala; tibiala, 6 barbed setae; genuala, 3 barbed setae; remaining segments with 3, 2, and 1 barbed setae. *Body setae:* Dorsal setae similar to scutal setae, arranged regularly 2.6.6.4.2.2. = 22 DS (34μ. HS 37μ) + 4 caudal setae (30μ) + VS (22μ).

Type Material.—Holotype, CORU.4097, and 5 Paratypes ex skink, R.31210 *Lygosoma olivaceum* Gray (Supple Skink), Bk. Lagong F.R., Kepong, Selangor, 12.ii.1953; and 1 Paratype ex lizard, R.39502, *Draco volans* Linn. (Common Flying Lizard), Ulu Langat F.R., Selangor, 15.ii.1955. Holotype (B.M.1956.8.21.8) and paratype deposited with the British Museum (Natural History), paratypes with U.S. National Museum, S. Australian Museum, and the author's collection.

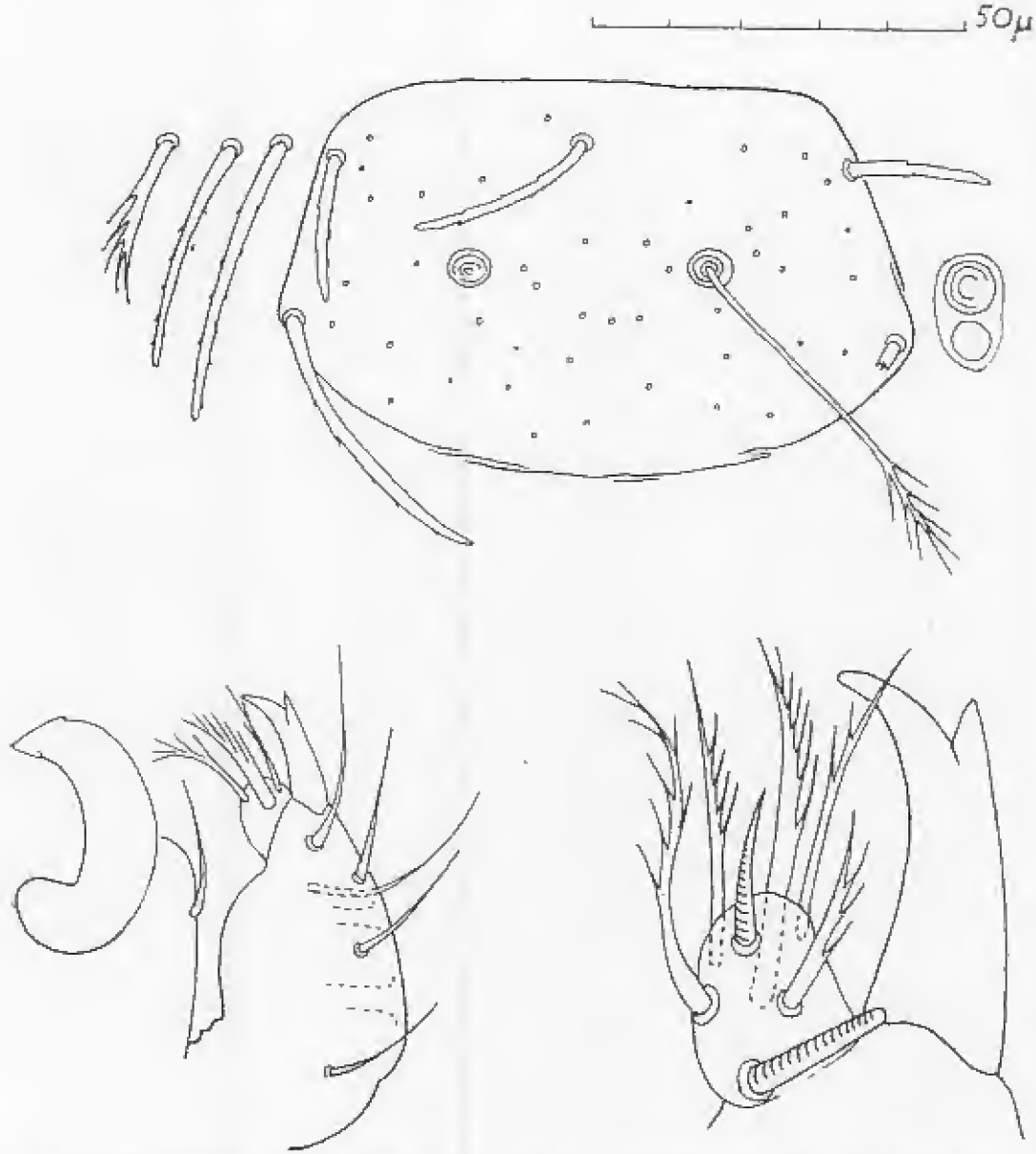

Fig. 4. *Eutrombicula fieldi* n.sp., scutum, eyes, body setae (humeral, dorsal, ventral), and details of gnathosome. (See also Fig. 5).

Comments.—The only significant feature which distinguishes the *fieldi*-group from *E. (E.) ablephara* and the African *lawrencei*-group is the number and arrangement of prongs on the palpal claw: the accessory prong is external in *fieldi*, ventro-internal in *E. ablephara*, and duplicated in the *lawrencei*-group. Although the tarsala-II is typically cylindrical and is often elongate and with a bulbous tip in the *lawrencei*-group, this character is not clearly developed in some species such as *gerrhosauri* (fig. 5).

This species is named for Dr. J. W. Field, C.M.G., Director of the Institute for Medical Research, whose retirement is unfortunately imminent. The history of intensive research into typhus and trombiculid mites in Malaya started with an outbreak of scrub typhus in an oil-palm estate near Sungei Buloh. The first cases from this estate were in 1926 and were observed by Dr. Field, then at the European Hospital, Kuala Lumpur (Fletcher & Field, 1929).

Siseca, New Genus

Type.—*Trombicula rara* Walch, 1923; Wharton & Fuller, 1952:69.

Diagnosis.—Trombiculids in the *Babiangia* complex (see p. 59 below) with large subquadrate or subrectangular scuta, extending behind posterolateral setae 2·5 or less times further than before anterolateral setae; ratio AW/SB about 1·4, PSB/ASB over 2·5. Palpal setae not heavily barbed but nude or with few inconspicuous barbs. Mastitarsala present. Empodia slightly thickened and claw-like. Larvae parasitic on reptiles (especially skinks) and in the case of *S. subrara* n.sp. on pill-millipedes, with host-range extending secondarily to mammals in *S. rara*. Nymphs (known for two species) have nude sensillae and no eyes.

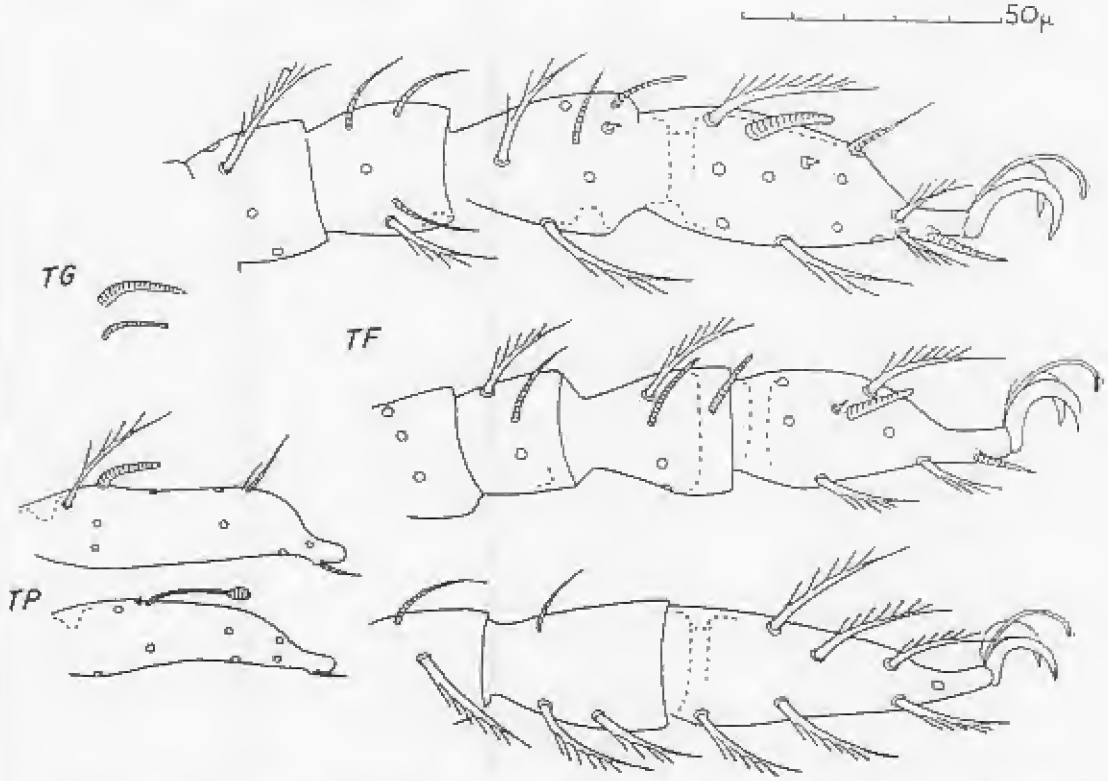

Fig. 5. *Eutrombicula fieldi* n.sp. (*TF*): details of chaetotaxy of legs, with details of tarsal chaetotaxy of two members of the African *lawrencei*-group for comparison: *TP*—*Eutrombicula pachydactyli* Lawrence, tarsi I and II, showing the full development of tarsala II: *TG*—*Eutrombicula gerrhosauri* Lawrence, tarsalae I and II, an example of minimal development of tarsala II which is however still subcylindrical. Apart from this and the 3-pronged palpal claw, *E. gerrhosauri* cannot be separated from the *fieldi*-group.

Species included in Siseca.—

Siseca rara (Walch), new combination

= *Trombicula rara* Walch, 1923:593; Wharton & Fuller, 1952:69, from reptiles and mammals (including man). Malaysia to New Guinea.

Siseca lundbladi (Womersley), new combination

= *Trombicula lundbladi* Wom., 1952:110, from a skink, New Guinea.

Siseca thori (Womersley), new combination

= *Trombicula thori* Wom., 1952:421, from a skink, Queensland.

Siseca subrara n.sp., from pill-millipedes, Malaya.

Comments.—Mr. Womersley has kindly lent type material of *lundbladi* and *thori* for examination. The scutum of *lundbladi* is redrawn in fig. 7: there is an extension of scutum beyond the AL and PL setal bases, and the scutum is not as subpentagonal as is suggested in Womersley's drawing (fig. 18A). Mastitarsala-III is present in both *lundbladi* and *thori*: the text of the original descriptions will require emendation accordingly.

This genus is named from the Malay word *sisek*, a scale: reptile-chiggers attach to their hosts under the scales.

Siseca subrara n.sp. (figs. 6 & 7)

Trombicula rara, Audy, 1950 (misidentification).

Trombicula (Neotrombicula) rara, Womersley, 1952:82 (larva), 355 (nymph), misidentification.

Trombicula (Trombicula) rara (in part), Wharton & Fuller, 1952:69 (ex millipede, *Zephronia*?, quoted from Audy, 1950).

Trombicula (*rara*-group) n.sp. nr. *rara*, Audy, 1954:148.

Diagnosis of Larva.—Differing from *rara* (see p. 60) in being pale, light yellow to yellow, instead of bright orange or red, and apparently host-specific to giant pill-millipedes; palpal formula N.N.NNN in *subrara*, B.N.NNN in *rara*; tarsi and tarsalae shorter in *rara* which has tarsus plus pretarsus-I 65 × 25μ, tarsala-I 15μ; tarsus and tarsala-II, 55μ and 13μ; and tarsus III 66 × 18μ. Differing from *thori* and *lundbladi* in the shape of the scutum.

Description of Larva.—Body: broad subglobular; medium and fully engorged larvae 460 × 350μ and 875 × 840μ. Colour pale yellow to light orange, contrasting with deep red of *rara*. Eyes 2 + 2, less distinct in old mounts than with *rara*: anterior eye larger; not as close to scutum as with *rara*. *Gnathosoma:* Chelicerae blade 42 × 9μ curved, tricuspid cap pointed. Galeal seta N. Palpal formula N.N.NNN, setae stout with dorsal tibial the longest, claw 2-pronged, axial prong (25μ) curved, stout dorso-external accessory prong straight, palpal tarsus with fairly long narrow basal tarsala, apical terminala, and 6 barbed or pectinate setae. *Scutum:* large distinct subquadrate with posterior margin rounded but flattened or slightly concave in midline; puncta small, close and numerous, evenly distributed to edges. AM seta slightly in advance of ALs with anterolateral shoulders of scutum rounded and not prominent; AM seta longer than ALs, shorter than PLs; setae with inconspicuous adpressed barbules. Sensillary bases about 60μ apart, relatively close to ALs, ASB:PSB being about 2:3 and ASB being only half or less than half AP. Sensillae roughly as long as distance between SBs, with 5–6 barbs in distal third.

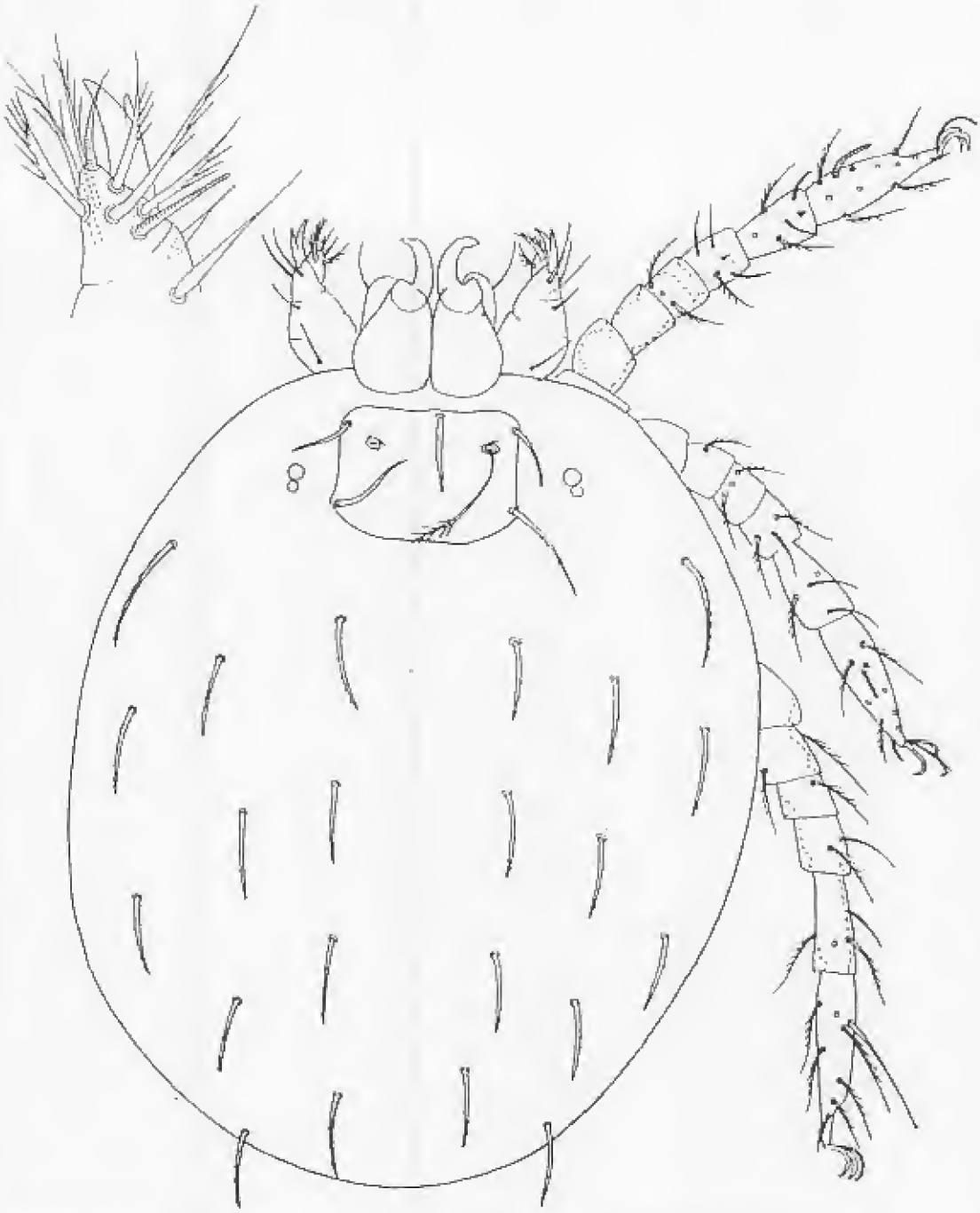

Fig. 6. *Siseca subrara* n.g., n.sp.: dorsum of partly engorged larva and details of palpal tarsus and tibia. (See also Fig. 7).

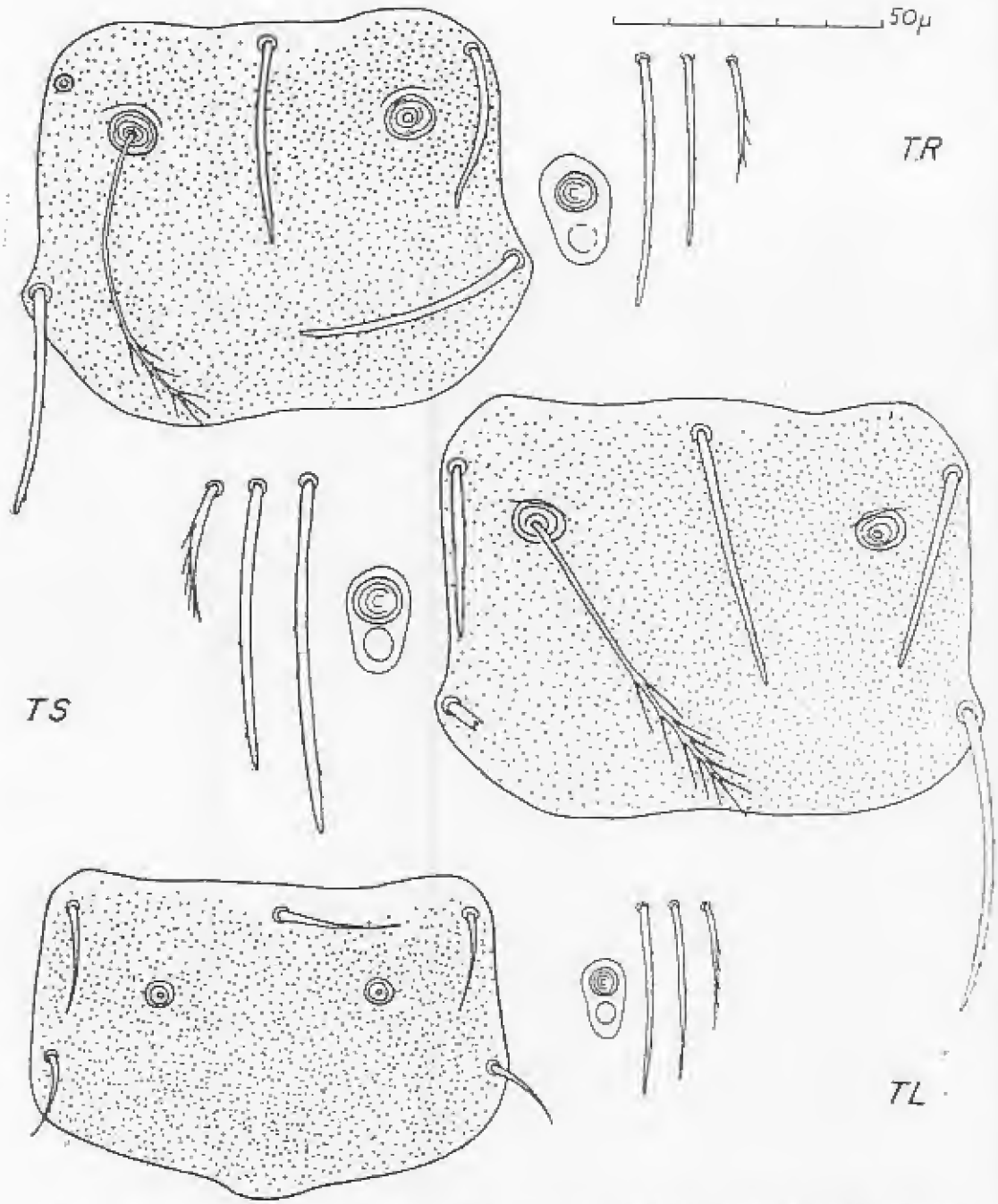

Fig. 7. *Siseca* n.g. (*Bahiangia* complex): scuta, eyes, and body-setae (humeral, dorsal, ventral). *TR*—*Siseca rara* (Walch) *TS*—*Siseca subrara* n.sp. (see Fig. 6) *TL*—*Siseca lundbladi* (Womersley) (the puncta are not arranged at random). The fourth member of this group, *Siseca thori* (Womersley), is not shown.

STANDARD MEASUREMENTS IN MICRONS, Holotype and 9 Paratypes of *Siseca subrara* n.sp., and Measurements of Related Species

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AM*	*AL*	*PL*	*Sens*
S. subrara										
Holotype	86·5	98	59	23	51·5	43	45·5	40	50	61
Means of 10	86·5	95·4	58·4	23·0	52·0	42·8	45·0	39·6	57·0	60·4
s.d.	2·24	2·22	1·42	1·23	2·26	0·98	1·12	1·10	1·78	2·00
S. rara										
Means, from Malaya?, after Wom., p. 427	87·6	94·8	59·0	21·4	53·0	41·7	43·9	38·0	55·0	58·7
S. rara										
Means of 27 from Philippines, after Womersley	74·5	85·4	54·9	19·8	51·8	36·5	27·5	24·8	32·3	49·2
S. loudbladi										
Means of 13, after Womersley	70·9	78·2	41·6	23·9	36·4	27·6	21·5	21·1	19·0	42·0
S. thori										
Means of 9, after Womersley	87·4	99·6	61·5	14·0	36·4	32·5	39·2	32·0	36·0	—

Legs: Coxae and legs punctate. Coxae unisetose, setae well developed and barbed. Ordinary leg setae roughly subequal (except for long trochanteric setae), barbed or pectinate. Empodia of all legs thickened and claw-like. *Leg I:* tarsus plus pretarsus 95μ × 26μ, tarsala (32μ) with microtarsala about halfway along its length distal to its bases, subterminala and parasubterminala, pretarsala, and 20 barbed setae; 2 tibialae, one being anterodistal to a slightly curved microtibiala, 8 barbed setae; 3 genualae, microgenuala, 4 barbed setae; remaining segments with 5, 1, 1 barbed setae each. Leg II: tarsus plus pretarsus 73μ, tarsala (20μ) with anteroproximal microtarsala, pretarsala, and 13 barbed setae; 2 tibialae, 6 barbed setae; 1 genuala, 3 barbed setae; remaining segments with 4, 2, 1 barbed setae each. Leg III: tarsus plus pretarsus 72 × 20μ, mastitarsala present, and 13 barbed setae; attenuated tibiala, 6 barbed setae; attenuated genuala, 3 barbed setae; remaining segments with 3, 2, 1 barbed setae respectively. *Body setae:* Dorsal setae (DS) similar to scutal setae but barbs generally more conspicuous, ventral setae with fewer finer barbs, with a tendency to increase in length laterally; arranged as follows: 2.6.6.4.4. = 22 DS (53μ, HS 65μ) + 6–8 caudal setae (CS, 45μ) + 6.4.2. = 12 VS (38μ) distinguishable from the CS.

Type Material.—Holotype, CORU.40976, and 9 Paratypes from giant pill-millipede, R.33769 *Sphaeropoeus globus-magiens* Jeekel, 1951. Dusun Wam, Bukit Lagong Forest Reserve, Selangor, roughly 10 miles NNW of Kuala Lumpur, 21.ix.1953. Holotype (BM.1956.8.21.8) and paratype deposited with the British Museum (Natural History), paratypes with U.S. National Museum, Rocky Mountain Laboratory, S. Australian Museum, Queensland Institute for Medical Research, and collections of acarologists.

Comments.—This species is common but apparently restricted to this local host. The larvae attach in colonies to the caudal intersegmental membrane and in groups or scattered on the intersegmental membranes generally. The millipedes first encountered were fairly common, mostly around dead logs in a small aboriginal village (Dusun Wam) deep in forest. Since this species was first found in 1948, over 1,500 specimens of *subrara* have been obtained from 57 out of 202 pill-millipedes examined from localities in Selangor, and other infested millipedes have been preserved. A single millipede may carry over 100 chiggers of *subrara*.

This species was to have been described in a forthcoming paper by Womersley & Audy on additions to the trombiculid fauna surveyed in Womersley's monograph. The writer is very grateful to Womersley for allowing him to describe it here so that the descriptions of arthropod-chiggers could be brought up to date.

The nymph of *subrara* has already been described under the name of *rara* by Womersley: it is to be redescribed, and that of *rara* itself is to be described, in the forthcoming paper noted above. The nymphs of the two species differ on casual examination more obviously than do the larvae: the dorsal setae particularly show differences. Both have nude sensillae.

Genus **Babiangia** Southcott, 1953, sensu lato, revised

Type.—Babiangia bulbifera Southcott, 1953, from a skink, New Guinea.

Diagnosis, revised.—Trombiculids in the *Babiangia* complex (see p. 59) which have large subpentagonal or subquadrate scuta, extended 3 or more times further behind posterolateral setae than before the anterolateral setae; ratio AW/SB about 1·4–1·8, PSB/ASB about 2 or less. Palpal setae nude or those on femur or genu with few inconspicuous barbs. Ventral setae and/or seta on coxa III with a tendency to basal swellings (figs. 8 & 9). Mastitarsala absent. Empodia definitely thickened and claw-like. Larvae parasitic on reptiles (especially skinks). The *nymph* of *B. parmifera* alone is known and is to be described shortly: it has long branches on the sensillae. Other comparisons with the nymphs of *rara* and *subrara* are premature.

Species included in Babiangia *sensu lato.*—

Babiangia bulbifera, Southcott, 1954:441, from a skink, New Guinea.

Babiangia parmifera (Womersley), new combination
= *Trombicula parmifera* Wom., 1952:109, from a skink, Malaya.

Babiangia booliati n.sp., from a skink, Malaya.

Babiangia booliati n.sp. (figs. 8 & 9)

Diagnosis of Larva.—Resembles *B. parmifera* (Wom.) but differs from it in the broader though equally deep scutum (AW over 67μ instead of under 63μ), the absence of bulbar swellings on coxal or ventral setae, and a more normal palp (palpal genu of *parmifera* is elongated and subcylindrical). Differs from *bulbifera* in the shape of the scutum, absence of swollen ventral setae, and relative enlargement of anterior instead of posterior eyes.

Description of Larva.—Body subovate, 460 × 350μ when partly engorged. Colour dark orange. Eyes 2 + 2 on ocular plate, anterior eye larger. *Gnathosome* elongated longitudinally with palpi arising anteriorly, setae on the fused coxal bases of gnathosome level with trochanter or basifemur of leg I. Cheliceral blade strongly curved and somewhat tapering. Galeal seta N. Palp N.N.NNN, setae on femur and genu shorter than those on tibia, tarsus with tarsala, terminala, and 6 barbed setae, one being long and with only 3–4 barbs. Claw (19μ) 2-pronged, accessory prong external and strongly developed. *Scutum* broad, subpentagonal, anterior margin slightly concave or sinuous, without AL shoulders, posterior margin strongly convex with rounded posterior angle; puncta fine and numerous over almost whole scutum; AM posterior to line of ALs and half AW in length, PLs slightly longer; setae with blunt shafts and inconspicuous barbules. Standard measurements as shown in the table. *Legs:* 7-segmented, tarsalae subequal.

STANDARD MEASUREMENTS IN MICRONS, *Babiangia booliati* n.sp. (Holotype & 2 Paratypes), *B. bulbifera* Southcott, and *B. parmifera* (Wom.)

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AM*	*AL*	*PL*	*Sens*
Holotype ..	71·5	86	53	19	41	26	42	26·5	44·5	42
Mean of 3	70·7	82·2	50·2	18·7	38·5	25	40·8	29	42·2	47·7
s.d. ..	1·93	2·78	2·87	0·47	1·48	0·71	1·25	1·87	1·39	4·03
B. bulbifera after Southcott	95	72	72	18	60	34	54	37	29	69
B. parmifera mean after Wom. ..	63	73	37	22	38	30	56	32	50	54

Coxae 1-setose, without basal expansions. Leg I: tarsus plus pretarsus 70 × 23μ, tarsala 15μ, microtarsala distal to its base, subterminala and parasubterminala, pretarsala, and 22 barbed or pectinate setae; 2 tibialae, distal one blunt, proximal pointed, 8 barbed setae; 3 genualae, microgenuala, 4 barbed setae; remaining segments with 5, 1, 1 barbed setae. Leg. II: tarsus plus pretarsus 54μ, tarsala (14μ) with microtarsala proximally, pretarsala, 16 barbed setae; 2 tibialae, and the distal one being longer, 6 barbed setae; 1 genuala, 3 barbed setae; remaining segments with 5, 2, 1 barbed setae. Leg III: tarsus plus pretarsus 64 × 11μ mastitarsala absent, 15 barbed setae, mostly ventral and posterior; 1 long tibiala, 6 barbed setae; 1 genuala, 3 barbed setae; remaining segments with 3, 1, 1 setae. *Body setae* generally similar to PLs with inconspicuous adpressed barbules, dorsally 2.6.6.4.4.2. = 24 DS (38μ, HS 42μ) + 4 CS + 8 VS (30μ), ventral setae being distinguished from caudal setae by being shorter, more tapering and with longer barbules.

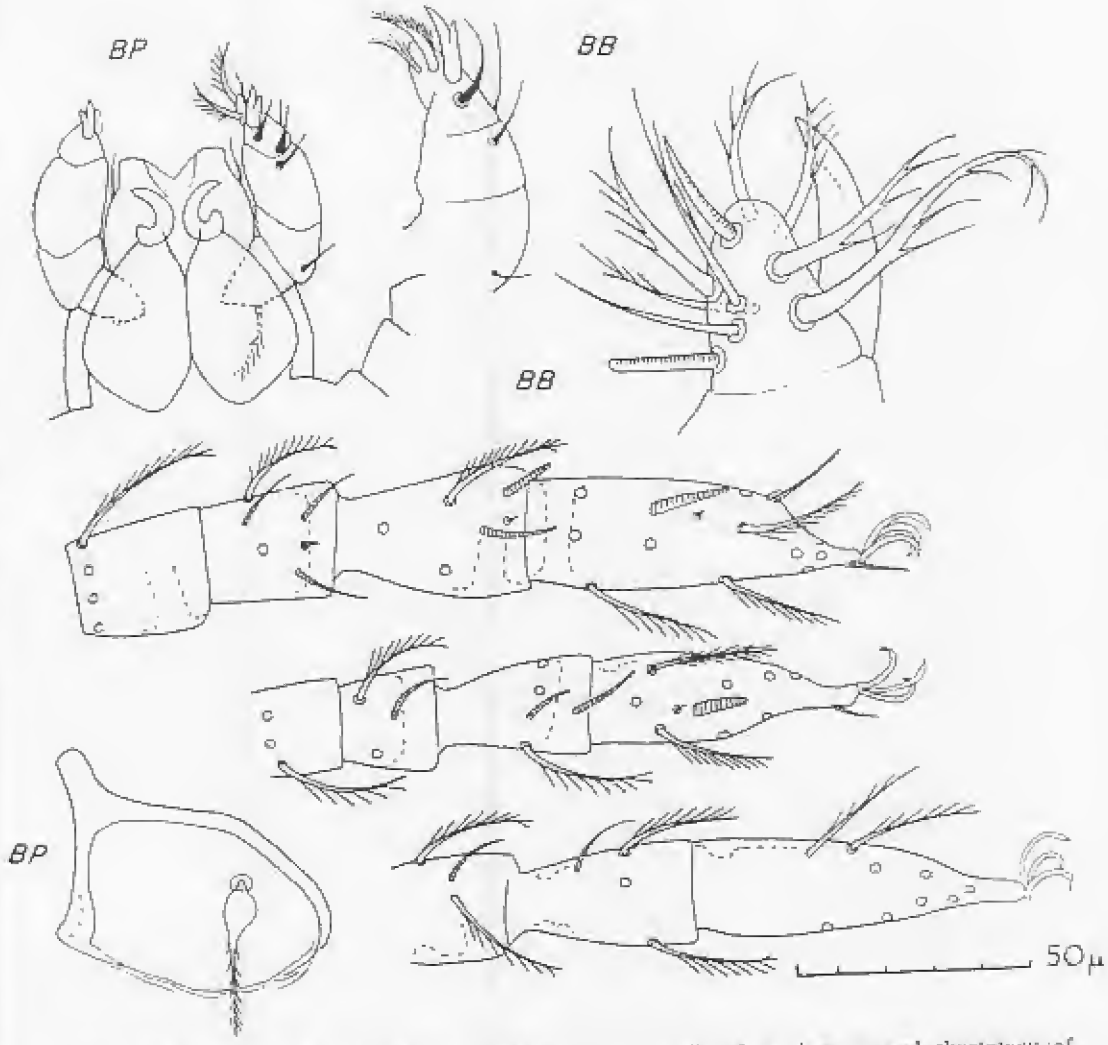

Fig. 8. *Babiangia* species: *BB—Babiangia booliati* n.sp., details of gnathosome and chaetotaxy of legs. *BP—Babiangia parmifera* (Womersley), gnathosome (to show general disposition of components) and coxa III (scales arbitrary). (See also Fig. 9).

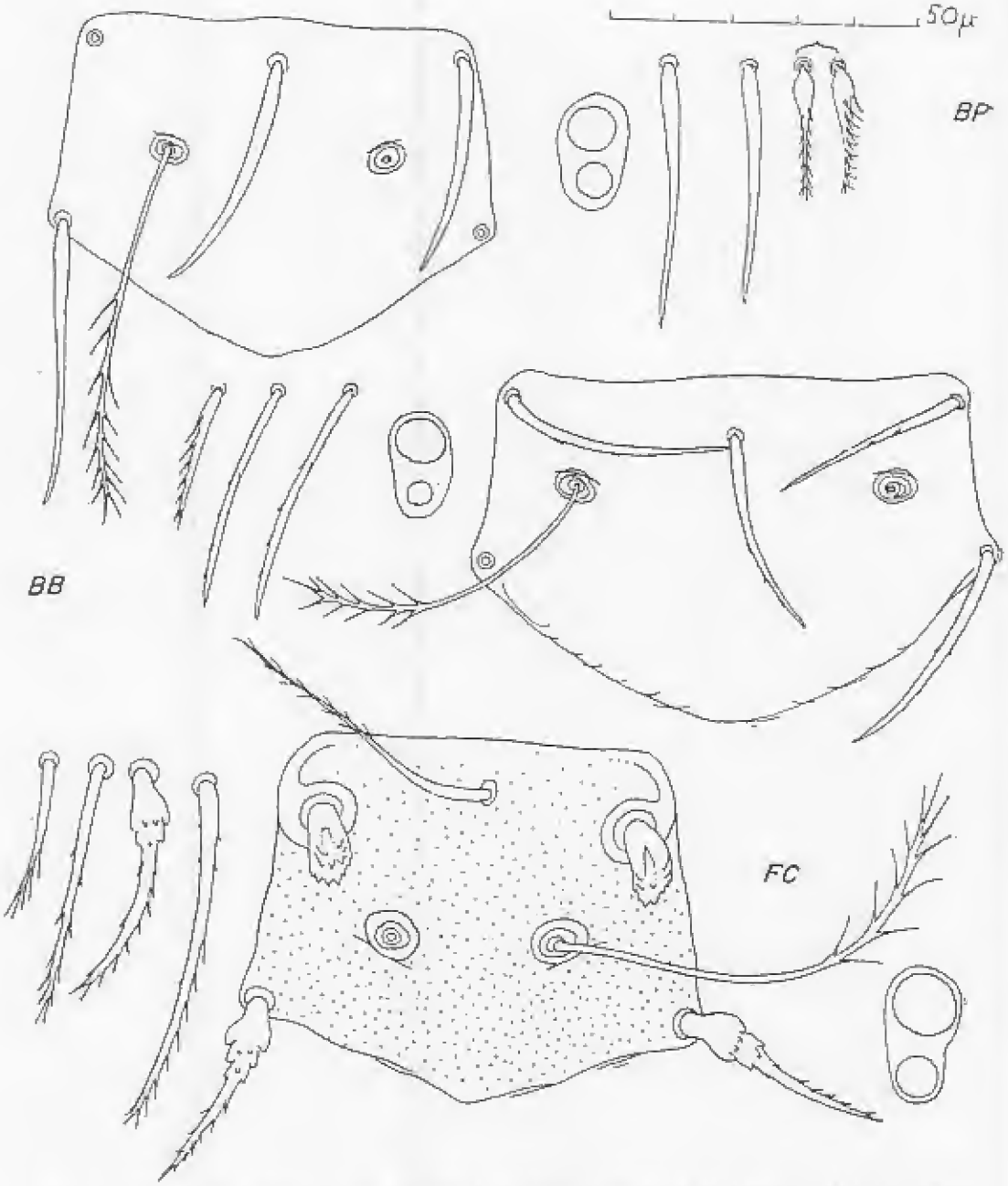

Fig. 9. *Babiangia* & *Fonsecia:* scuta, eyes, and body setae (humeral, dorsal, ventral), *BP—Babiangia parmifera* (Womersley). *BB—Babiangia boolutti* n.sp. *FC—Fonsecia celestroe* n.sp., with modified submedian anterior dorsal seta and caudal seta. (See also Figs. 8 & 10).

Type Material.—Holotype, CORU.40801, and 1 Paratype ex skink, R.14574, *Mabuya multifasciata* (Kuhl) (Common Skink), Ulu Langat F.R., Selangor, 17.iv.1951; and 1 Paratype ex same species, R.14588, Sungei Buloh, Selangor, 18.v.1951. Holotype (B.M. 1956, 8.21.10) deposited with the British Museum (Natural History), one paratype with U.S. National Museum, and one paratype with the author's collection.

Comments.—This species is named for Lim Boo Liat, Senior Laboratory Assistant in charge of vertebrates in the Division of Virus Research and Medical Zoology, Institute for Medical Research. Mr. Lim has put a great deal of work into the collection of reptiles and birds and the writer is grateful to him for his efforts in checking the identification of the birds, listed in the present paper (p. 66). *Babiangia booliati* was referred to as "*MAB* n.sp. in MS" by Audy, 1954:148.

Genus **Fonsecia** Radford, 1942

Type.—*Trombicula ewingi* Fonseca, 1932:153, from a snake, Brazil.

Note.—This genus is discussed by Audy (1954:148).

Fonsecia celesteae n.sp. (figs. 9 & 10)

Diagnosis of Larva.—Differs from all known species of *Fonsecia* in having the posterolateral scutal setae and anterior dorsal setae conspicuously modified by peculiar basal swellings, the anteromedian scutal seta being normal.

Description of Larva.—Body large, broad subovate, 660 × 461μ in partially engorged larva. Colour yellow. Eyes 2 + 2 on ocular plate, posterior eyes smaller than SBs, anterior eyes slightly larger than SBs. Cheliceral bases rounded, with fine punctae posteriorly. *Gnathosoma:* Chelicers (blade 22μ) with tricuspid cap exaggerated, also with a small tooth on the dorsal aspect. Galeal seta nude and strong, basally distinctly expanded but apically fine and tapering. Palpal formula B.N.NNB, the nude setae fine and tapering with the ventral tibial seta longest and most conspicuous; palpal tarsus with blunt cylindrical tarsala, a longer terminala, and 6 barbed setae of which 5 are pectinate; palpal claw (18μ) with 2 prongs, the axial being curved towards the apex and the accessory prong being small ventroexternal. *Scutum* generally subquadrate except for the obtusely angulate shallow posterior border which makes it subpentagonal; anterior margin extended anteriorly, nearly straight with the AL shoulders reinforced by chitinous extensions from the AL bases; lateral margins almost straight. Finely punctate, about 10–15 puncta in circle with diameter of a sensillary base, extending over almost the whole scutum. AM seta anterior to lines of ALs, 56μ long, shaft tapering, barbs not long or conspicuous; AL setae greatly modified, broad sessile and spoon-shaped, 15 × 7μ, with the edges produced into regular short blunt barbs or processes partly covering the bowl (fig. 9). PL setae expanded immediately beyond the bases, rapidly narrowing to a normal shaft with small barbules, the bases of barbs represented on the swollen part as pips or nubbins (fig. 9). Sensillary bases fairly well apart (SB 26μ) and posterior to the midline of the scutum; sensillae with 10–15 branches or long barbs in the distal half. Standard measurements as shown in the table.

Standard Measurements in Microns, *Fonsecia celesteae* n.sp. (Holotype & 2 Paratypes)

	AW	*PW*	*SB*	*ASB*	*PSB*	*A-P*	*AM*	*AL*	*PL*	*Sens*
Holotype ..	50·5	68	25	32	28	32	57	14·5	30	85
Means of 3	51·3	67·6	25·8	31·5	28·5	31·7	56·5	14·7	29·3	83·2
s.d. ..	1·08	0·85	1·18	0·40	1·87	0·47	0·50	0·24	0·47	1·75

Legs: 7-segmented, with the ordinary setae pectinate and fairly long. Coxae with 1 seta each. Leg I: tarsus plus pretarsus elongate, 108 × 22μ, tarsala (30μ) with blunt microtarsala more than half way along its length, subterminala slightly shorter than tarsala, parasubterminala, pretarsala, and 23 barbed setae; 2 tibialae, the anterodistal one being thick, blunt, with a curved microtibiala immediately posterior to its base, the posteroproximal tibiala tapering, and 8 barbed setae; 3 genualae, curved microgenuala, 4 barbed setae; remaining segments with 5, 1, 1 barbed setae. Leg II: tarsus plus pretarsus 82μ, tarsala 20μ, microtarsala proximal and close to its base, pretarsala, and 15 barbed setae, the proximal dorsal barbed seta being longer than the rest; 2 tibialae, distal one longer stouter and blunt-tipped.

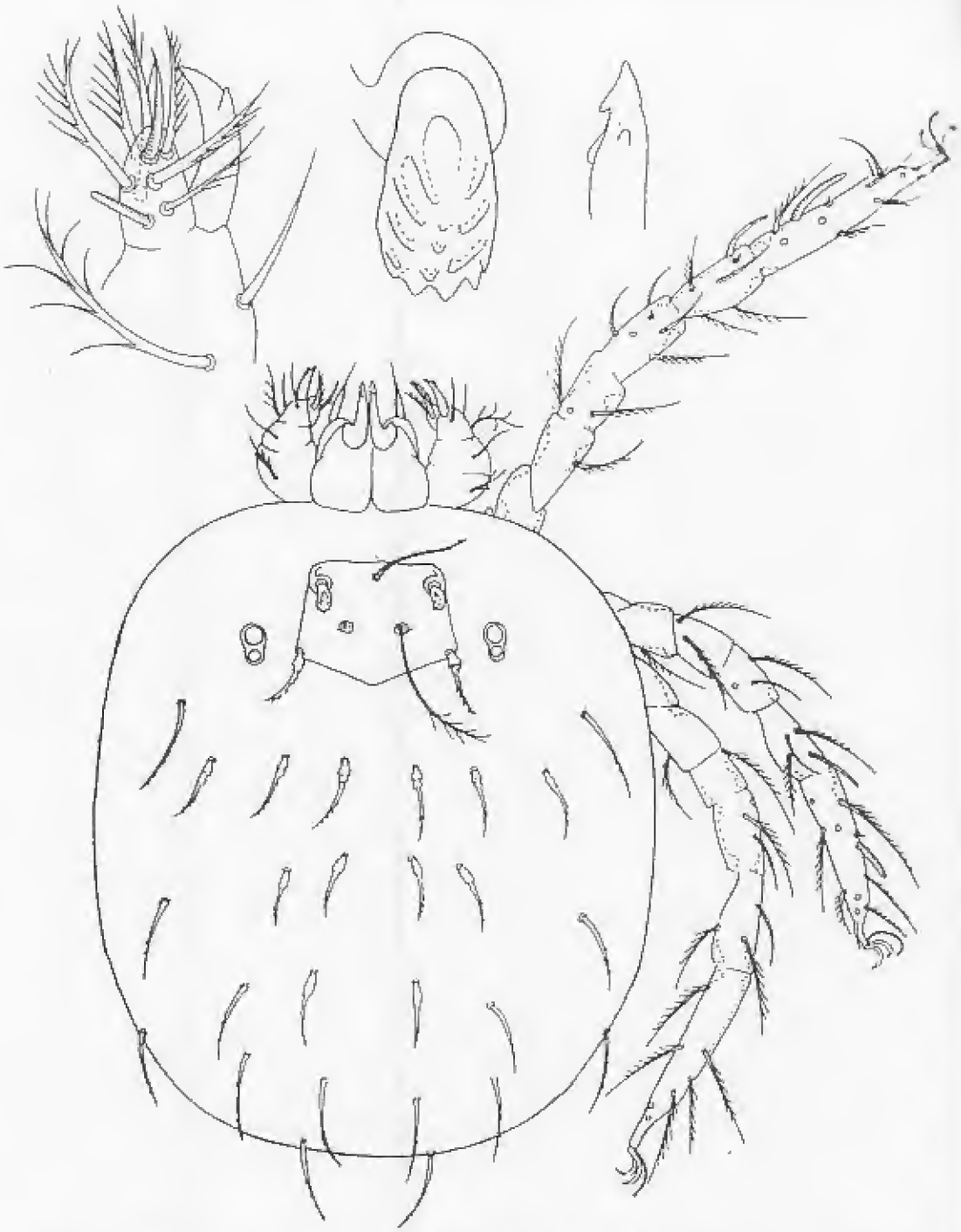

Fig. 10. *Fonsecia celestinae* n.sp: dorsum of partly engorged larva and details of chelicer, palpal tarsus and tibia, and modified anterolateral scutal seta.

proximal one tapering, and 6 barbed setae; genuala, 3 barbed setae; remaining segments with 4, 2, 1 barbed setae. Leg III: tarsus plus pretarsus 96 × 18μ, mastitarsala absent, 15 barbed setae; 1 tibiala, 6 barbed setae; 1 genuala, 3 barbed setae; remaining segments with 3, 2, 1 barbed setae. *Body setae:* The anterior and medial dorsal setae are modified by basal swellings in the same way as the PL scutal setae, getting less marked in posterior rows and laterally. The humeral setae are long and unmodified. The first row of 6 DS are all modified; the medial 4 of the second row are modified (though to a lesser degree) but the lateral 2 are normal; the 2 submedian setae in row 3 are slightly modified. The shafts of these setae carry small barbs mostly in the distal half or third, and they may appear almost nude. The dorsal setae are arranged in rows, 2.6.6.6.4.2. = 26 DS (42μ, HS 68μ) + 8 caudal setae (CS 53μ) + 12 VS (50μ), distinguishable from the caudal setae by their shorter length and more obvious barbs.

Type Material.—Holotype, CORU.35961, and 2 Paratypes, ex snake R.31816 *Natrix triangaligera* (Boie) (Triangle Keelback), Bukit Lagong F.R., Kepong, Selangor, 18.iii.1953; and 1 Paratype ex skink, R.31608, *Mabuya multifasciata* (Kuhl) (Common Skink), Bk. Lagong F.R., Kepong, Selangor, 2.ii.1953. Holotype (BM. 1956.8.21.11) deposited with British Museum (Natural History), one paratype with U.S. National Museum, and two paratypes with the author's collection.

Comments.—The highly modified AL setae (fig. 9) somewhat resemble a partly closed hand, and from the description and drawings of *F. travassosi* (Fonseca) it would appear that the AL setae of *travassosi* are of similar structure, enclosing a hollow but without the finger-like processes. Comments on the possible relationship borne by modified setae to embryological organizer fields have been made elsewhere (Audy 1954:148). The AM seta appears to have special individuality, which is expressed by (*a*) its lack of modification in *F. celestei, ewingi,* and *coluberina,* while the ALs are modified, (*b*) its absence in *Gahrliepia* (sensu lato), and (*c*) its apparent homology with the teetal (epistomal) seta of the postlarval stages. The PL setae however appear to be related to the anterior dorsal setae and the PLs and DS are frequently modified together as in *F. celesteae* and the subgenus *Trombiculindus.*

The peculiar proximal thickening of the galeal seta resembles that of *Siseca thori.* The basal swellings of the PLs and DS bear blunt processes obviously representing barbs, showing these much more clearly than do the basal swellings of DS and VS in *Euschöngastia causicola* (Jadin & Vercammen-Grandjean) and those of the VS and coxal setae in *Babiangia* (see p. 61).

This species is named for Miss Celeste Woodward, aged 9, daughter of Dr. and Mrs. Theodore E. Woodward of Baltimore. Dr. Woodward, now Professor of Medicine in the University of Maryland, was associated with investigations of scrub typhus and trombiculid mites in the Philippines and Japan during World War II, and he was the physician in the research team led by Dr. Joseph E. Smadel, which came to Malaya in 1948 for field trials of chloramphenicol (chloromycetin), the first dramatically successful agent to cure scrub typhus.

Genus **Trombicula** Berlese, 1905, sensu lato

Type.—Trombicula minor Berl., 1905, adults from bat-guano, Java.

Vercana, New Subgenus

Type.—Trombicula vercа Traub & Audy, 1954:47, from a bird, Borneo.

Diagnosis.—Species of *Trombicula,* sensu lato, the larvae of which have well-chitinized subrectangular scuta with sensillary base placed near the line of the PL setae, a conspicuous large chitinized anterior eye and a small or rudimentary posterior eye; palpal formula B.B.NNb with femoral and genual setae very strongly developed and

barbed; claw typically 3-pronged with accessory prongs ventrally disposed; galeal setae nude; leg I with 2 genualae; no mastitarsala III (but present in *T. thompsoni* Brennan). Larvae primarily parasitic on birds, possibly reptiles; but host range extends to mammals. *Nymphs* (known only for form near *vorca* from North Borneo) with most of the dorsal setae greatly exaggerated (these nymphs are to be described in a later publication when further diagnostic points will emerge).

Species included in Vorcana.—

Trombicula (Vorcana) corvi, Hatori, 1920, from birds, Formosa. This appears to be a typical member except for the doubtful sensillae.

Trombicula (Vorcana) densipiliata, Waleh, 1822, "rat"? from Sumatra.

Trombicula (Vorcana) sp. cf. *densipiliata*, Womersley, 1952:126: two forms, one from a log on Halmahera, and another from a rat in the Solomons.

Trombicula (?Vorcana) nissani, Dumbleton, 1947 from a "cuscus" (a phalanger or possum), New Guinea. This species has a 3-pronged palpal claw like the others (Womersley, 1952:113) but it has relatively few dorsal setae (28). It superficially resembles *T. (Leptotrombidium) gliricolens* (Hirst) and its relationships will require further study.

Trombicula (?Vorcana) thompsoni, Brennan, 1952, from a bird, Jamaica. This has a mastitarsala-III and 2-pronged palpal claw but in other characters fits well into this group, of which it is the only representative known from the New World.

Trombicula (Vorcana) vorca, Traub & Audy, 1954:47, from a bird, Mt. Kinabalu, North Borneo.

Trombicula (Vorcana) sp. near *vorca*, Traub & Audy, 1954:48, common on crow-pheasants at Beaufort, North Borneo; reared to the nymph and being studied further.

Comments.—The writer believes that this group is sufficiently distinct in larvae and, apparently, nymphs, to be made a full genus when further studies have been completed. He prefers to disagree with the original description of *T. corvi* Hatori, 1920, where it states that only the *proximal* half of the sensillary shafts is barbed: *T. corvi* obviously conforms to this group in all other characters and the unique placing of the sensillary barbs should be looked upon as a *lapsus calamae* until the species is rediscovered and this feature checked. The reconstruction of the scutum of *corvi* by Womersley (1952: plate 23A) is especially open to the objection that the posterior margin cannot be reconstructed.

In addition to the species listed above, the following are known only as adults and will require comparison with the nymphs from Borneo:—

Trombicula canestrinii (Bulfa, 1899), Wom., 1952:357, adults from Europe. The adults share the extraordinary long tufted dorsal setae of the Borneo species and may be related.

Trombicula strinatii, Cooreman, 1951, adult from Morocco, closely related to *T. canestrinii*.

This subgenus is to be revised when the nymphs are described. It is introduced to this paper because *T. vorca* and possibly other related forms are bird-chiggers in Malaysia and may be expected to occur in Malaya. .

The name of this subgenus is derived from the name of the type-species, which itself is from an anagram of *corvi*, in the belief that *T. corvi* and *T. vorca* are almost identical in spite of the description of the sensillae of the former.

Relationships of Reptile Chiggers

The genera *Trombicula*, *Neoschöngastia*, and *Euschöngastia* are heterogeneous and troublesome to the taxonomist, and there is a lack of balance between various other recognized genera and certain groups or species which have been retained in these heterogeneous genera. Many species of *Trombicula* exist which cannot be placed in any recognized subgenus without making one or more subgenera into taxonomic trashcans. The guidance which was expected from studies of the post-larval stages is not yet apparent: in spite of the pioneer work of Womersley (1952), it now appears that few characters of real taxonomic importance in postlarval stages have been found. In the case of the reptile-chiggers there is a singular lack of postlarval material except for *Eutrombicula* s.s. and three groups (*Eltonella*, *Siseca*, *Babiangia*) represented in Malaya. In these conditions, it is worth stressing the value of recognizing even small or monotypic species-groups, naming each of these by a representative species, and treating them tentatively as proto-subgenera although the groups may range in status from simple species-complexes to subgenera or even genera. The creation of further new subgenera or the revision of those genera already known, may then await studies of both postlarval and larval stages of several species in the groups. A number of species-groups tentatively proposed in an earlier paper (Audy, 1954) are defined in more detail in the present paper while some are named as subgenera or genera. Some new groups are also proposed.

A number of important groups related to *Trombicula* appear to be shared by reptiles and birds. The recurrence of 3 instead of 2 genualae-I in these has been noted above. All those species so far known to possess eyes in the nymphs or adults belong to certain groups essentially parasitic on amphibians, reptiles, or birds; single eyes away from the crista in *Blankaartia* and *Heaslipia* (p. 62), single eyes close to the sensillary bases in *Eutrombicula* s.str., *E. (Eltonella) eltoni*, and *Ipotrombicula* (of which the host is however unknown), double eyes away from the crista in *Hannemania* (hypodermal in amphibians, Ewing, 1926). Only two species of trombiculines (*S. subrara*, *E. eltoni*, above) are definitely known to parasitic arthropods regularly (see p. 74 below), and both these belong to groups of reptile-chiggers. If the affinities between reptile-chiggers and bird-chiggers have a phylogenetic basis, then the parent stems may date back to the Jurassic. The relationships of these chiggers are in any case exceptionally interesting, because birds evolved from the reptiles at a considerably later date than did the mammals.

After studying the Malayan material as well as a valuable collection of African reptile-chiggers which Dr. R. F. Lawrence kindly made available, and some type-material in the British Museum (Natural History) and the London School of Hygiene and Tropical Medicine, the writer has revised a number of his ideas and is inclined to consider that probably all the true reptile-chiggers placed in *Trombicula* are likely in due course to be removed from that genus and to arrange themselves in or around *Eutrombicula*, *Blankaartia*, *Fonsecia*, *Siseca* and *Babiangia*. Also, *T. ilesi* appears to be more nearly related to the subgenus *Eutrombicula* than to *Eltonella* and the main *lawrencei*-group of African reptile-chiggers: the *ilesi*-group plus the *lawrencei*-group of Audy (1954:148) can now be seen to comprise (*a*) *ilesi* by itself, (*b*) *frittsi* as a member of a different new group (*Eltonella*, p. 32), and (*c*) the remaining species

which are here referred to as the *lawrencei*-group, sensu lato (p. 31). Finally it appears that *Blankaartia* and *Heaslipia* are sister genera; that *Babiangia bulbifera* (type of the genus) may be a somewhat atypical member of the natural group to which it rightly belongs, so that the genus may therefore be regarded in a broader sense; and that *Sauriscus* is unrelated to *Tecomatlana* (of which it is generally considered a subgenus)—it appears to be derived from the *lawrencei*-group. The lack of balance between some species (e.g. *T. geckobia* Wom.) within *Trombicula* (sensu lato) and genera outside it must be accepted until further studies clarify matters. The relationships of these reptile-chiggers to *Trombicula*, sensu stricto, appear at present to be on some such lines as the following:—

Genus *Trombicula:* The subgenera *Trombicula*, *Crotiscella*, *Miyatrombicula*, *Euschöngastoides*, *Leptotrombidium*, *Trombiculindus*, *Neotrombicula*, and many species of uncertain status, appear to be generically separable from the following groups, one of which is tentatively retained in *Trombicula:*—

Eutrombicula s.l.

1. *Eutrombicula* s.s. (*T. ilesi* from same parent stem?), p. 31.
2. *lawrencei*-group (same parent stem as *Sauriscus*), p. 31.
3. *fieldi*-group (might demand inclusion in the *lawrencei*-group), p. 38.
4. *Eltonella* (possibility of this linking *Eutrombicula* with *Fonsecia* may be entertained), p. 32.

Fonsecia (from same parent stem as *Eutrombicula*?), p. 49.

Blankaartia & *Heaslipia*, pp. 61–63.

Babiangia, *Siseca*, *Novotrombicula* (apparently from same parent stem), p. 59.

Vorcana, p. 51, unrelated to any of the above.

Neotrombicula, which should be restored to generic rank, would be included in the *Blankaartia* complex except for the fact that they appear to be mammal-chiggers and the post-larval stages lack the conspicuous paracristal eyes of *Blankaartia* and *Heaslipia*. A detailed comparison is necessary, for Audy (1951:96), in discussing trombiculids which cause scrub-itch, suggested that the primary or historical hosts of *Neotrombicula* may not have been mammals.

Nymphs or adults are known only for a few species of *Eutrombicula (Eutrombicula, Eltonella)*, *Blankaartia*, *Heaslipia*, *Babiangia*, and *Vorcana*. Not only does this leave serious gaps, but the known nymphs and adults themselves have not yet been fully studied and compared. A comparative study of the leg-chaetotaxy of nymphs is progressing slowly, on the lines described elsewhere (Audy, 1954:129), but it is premature to discuss the results, which appear promising. The nymphs of *S. rara*, *S. subrara*, *B. parmifera* and some other species are being described or redescribed by Womersley & Audy (paper in preparation) and their study might throw light on relationships in the *Babiangia* complex. Nymphs have been reared of the following trombiculids discussed in the present paper: species near *T. vorca*, *Eutrombicula (Eutrombicula) wichmanni*, *E. (Eltonella) eltoni* n.sp., *Siseca rara*, *S. subrara* n.sp., *Babiangia parmifera*, *Blankaartia acuscutellaris*, *Heaslipia gateri*, *Euschöngastia (Laurentella) indica*, *E. (Walchiella) oudemansi*, and *Neuschöngastia gallinarum*. Most of these nymphs have been described by Womersley (1952).

Tentative Key to Relevant Genera and Groups, Trombiculinae and Gahrliepiinae

The following key has been designed to bring out the genera and species-groups relevant to the present paper, to give a summary of the main diagnostic characters of the groups, and to contrast confusingly similar groups (e.g. *Neotrombicula* and *Blankaartia*) as well as somewhat dissimilar but apparently related groups. It purposely contains more data than are needed for, and a number of features undesirable in, a straightforward dichotomous key. It has not been tested by usage.

Tentative Key to Relevant Genera and Groups, Trombiculinae and Gahrliepiinae

1. Empodium modified, with spatulate or pulvilliform tip ..... *Riedlinia* Ouds.
   Empodium claw-like ..... *Mackiena* Traub & Evans 2

2. Cheliceral blade modified: short, stout, with terminal or subterminal processes *Oenoschöngastia* Wom & Kohls and *Myotrombicula* Wom & Heaslip
   Cheliceral blade sword-like, without such processes 3

3. Sensillae expanded distally 4
   Sensillae attenuated or flagelliform 5

4. *Tibiala III present, 2 or 3 genualae I ..... *Euschöngastia* Ewing (subgenera *Euschöngastia*, *Walchiella* Fuller, *Helenicula* Audy, *Laurentella* Andy, and several distinct species groups), *Ascoschöngastia* Ewing, *Pseudoschöngastia* Lipovsky, *Schöngastia* Ouds., *Radfordiana* Wom., *Neoschöngastia* Ewing, *Endotrombicula* Ewing (incl. subgenus *Phrynacarus* Lawr.)
   Tibiala III absent, 2 genualae I ..... *Schauinslandiella* Jadin & Vercammen, *Deloisia* Ouds., *Guntheriana* Wom & Heaslip, *Gahrliepia* Ouds. (subgenera *Gahrliepia*=*Gateria*, *Walchia* Ewing, and *Schöngastiella* Hirst, *Fainiella* Verc.)

5. Legs 7–6–6– or 6–6–6–segmented 6
   Legs 7–7–7–segmented 7

6. Posterolateral setae not on scutum, legs 7–6–6–segmented ..... *Anomalaspis* Brennan
   Posterolateral setae on scutum, legs 6–6–6– or 7–6–6–segmented ..... Subgenus *Trombicula*, *panieri*-group in part; *Trombicula geckobia* Wom.

7. Posterolateral setae not on scutum 8
   Posterolateral setae on scutum 9

8. Eyes single, palpal claw 2-pronged, tarsala II longer than tarsala I and with bulbous tip; antero-distal tibialae I and II greatly expanded, stump-like; on reptiles. Africa *Sauriscus* Lawr., p. 22
   Eyes double, palpal claw with more than 2 prongs, tarsala II shorter than tarsala I and not with bulbous tip; tibialae normal; on mammals (Bats). Old & New Worlds *Tecomatlana* Hoffman

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* Only these particular chiggers with expanded sensillae include true reptile chiggers. The subgenera *Walchiella*, *Helenicula*, and *Laurentella* appear to be true mammal-chiggers occurring casually on birds. The subgenus *Euschöngastia*, sensu stricto, is likewise essentially a mammal-chigger group, but many others at present accommodated in the genus *Euschöngastia* appear to belong to groups of true reptile-chiggers: Lawrence's species from Africa (his pp. 431–437, 461–462) are at least subgenerically distinct. Of the remaining genera in this couplet, *Ascoschöngastia* and *Pseudoschöngastia* appear to form a generic complex with *Laurentella*, as discussed elsewhere (this *Bulletin*, Audy 1956, p. 20). *Schöngastia* appears to be essentially a bird- and reptile-chigger genus, a number of members of which also feed on mammals. *Radfordiana* certainly, and *Oenoschöngastia* possibly, might reasonably be regarded as subgenera of *Schöngastia* on larval characters. *Endotrombicula* is a group of hypodermal chiggers feeding on amphibians: it appears to the writer that *Phrynacarus* itself, and possibly the other species excepting *E. lyrmi* (Ew.), have probably been derived from a common stem with *Schöngastia*. *Neoschöngastia* (p. 64) is almost confined to birds but some species may also feed on reptiles or mammals.

9. Scutum large (AW over 65μ) and deep, with sensillary bases wide apart and relatively close to line of anterior setae, ratios PSB/ASB and SB/ASB 1·6 to over 3 (both ratios under 1·6 in most trombiculids); and ratio AW/SB 1·3–1·8 (about 2 more in most trombiculids); galeal seta nude ..... (*Bahiangia* complex, p. *59*) 10

Scutum large or small, sensillary bases more normally placed nearer line of posterolateral setae (PLs), may be in line with or posterior to PLs; either or both ratios PSB/ASB and SB/ASB under 1·6, ratio AW/SB over 1·9; galeal seta nude or barbed 12

10. Scutum with seven setae; empodium normal (?); host unknown ..... *Novotrombicula* Wom. & Kohls, p. *59*

Scutum with usual five setae; empodium more or less blade-like, resembling the claws; hosts primarily reptiles (only *T. rara* recorded casually on mammals) 11

11. Scutum subquadrate or subrectangular, with posterior margin convex, not greatly extended posteriorly, flattened or indented in midline; no basal swellings on body setae or coxal setae; empodium slightly thickened; mastitarsala III present [Nymphs with nude sensillae, without eyes] ..... *Sinecu*, n.g., p. *41*

Scutum subpentagonal with anterior eye slightly larger than posterior, *or* scutum extended posteriorly and flattened, with posterior eye larger; ventral and/or third coxal setae with basal swellings or as described on p. 46; empodium obviously thickened; mastitarsala III absent. [Nymphs of *B. parmifera* with branched sensillae, without eyes] ..... *Bahiangia* Southcott, sensu lato, p. *46*

12. Scutum subpentagonal, and at least the anterolateral scutal setae modified, short and swollen; on reptiles (especially snakes) ..... *Fonsecia* Radford, p. *59*

Scutum pentagonal or otherwise, anterolateral scutal setae not short and swollen 13

13. Scutum pentagonal or subpentagonal; coxa III with 2 or more setae, 2 genualae I present; setae on palpal femur and genu barbed or plumose; parasitic on mammals ..... subgenus *Miyatrombicula* Sasa et al. (= *cynos*-group, Brennan)

Scutum pentagonal or otherwise, coxa III with one seta 14

14. Palpal claw 2-pronged, with one accessory prong placed internal (or ventral) to axial prong; 3 genualae I present 15

Palpal claw with more than one accessory prong, or if only one then placed external or dorsal to axial prong; 2 or 3 genualae I present 16

15. Scutum not large (AW less than 55μ), sharply pentagonal (AW & SD subequal); accessory palpal claw ventral, mastitarsala III absent; palpal formula B.N.BNB, with dorsal tibial seta strongly developed and barbed; parasitic on reptiles (snake) [Nymphs and adult unknown] *Trombicula* [*?Entrombiculal ilesi* Rad., p. *32*

Scutum larger and broader (AW more than 60μ, usually about 80μ) posterior border convex but scutum exceptionally pentagonal, fairly strongly punctate or striate-punctate; mastitarsala III present; palpae usually B.B.NNB; usually parasitic on reptiles, secondarily on birds or mammals. [Nymphs and adults typically with eyes placed close to sensillary area*] subgenus *Entrombicula* Ewing, p. *31*

16. Scutum with more than 5 setae; probably usually parasitic on water-birds but also on mammals. [Nymphs with eyes placed away from crista, and sensillae nude, flagelliform] .... *Heaslipia* Ewing, p. *62*

Scutum with 5 setae 17

17. Scutum pentagonal or subpentagonal; scutum, coxae, and gnathobase heavily punctate or striate-punctate; 3 genualae I and one mastitarsala III present, mastitibialae or masti-femoralae absent, and nonsensory setae on legs subequal and strongly barbed; galeal setae B or N, palpal formula B.B.N(b)N(b)B, palpal claw 3-pronged; usually parasitic on water-birds (and possibly on reptiles), secondarily on mammals. [Nymphs and adults with eyes placed away from crista, and sensillae nude, flagelliform] ..... *Blankaartia* Ouds., p. *61*

Not with the above combination of characters 18

18. Scutum pentagonal or subpentagonal; coxae and gnathobase not heavily striate-punctate; 2 (exceptionally 3) genualae I; one or more mastitarsalae III present and either nude whip-like setae (masti-setae) or elongated finely plumose setae present on some of the segments of leg III other than the tarsus; nonsensory setae on all legs generally lightly feathered or plumose.

* *Ipatrombicula* Wom., known only as an adult, has eyes placed close to the sensillary area; so also do nymphs of *T. eltoni* (see couplet 22 and p. 53).

and unequal; galeal seta N or B, palpal claw 3-pronged; usually parasitic on small terrestrial mammals but may be on birds (*T. autumnalis*). [Nymphs and adults without eyes] subgenus *Neotrombicula* Hirst, p. 54

Not with the above combination of characters 19

19. Three genualae I present 20

Less than three genualae I present 24

20. Parasitic on mammals (especially bats); scutum small (AW less than 50μ) and SB about 20μ or less; anterior border sinuous, usually with definite anterolateral shoulders; if subpentagonal then posterior angle very obtuse and posterior margin concave between midline and PL bases; palpal claw often 3-pronged 21

Parasitic on reptiles; scutum either obviously subpentagonal or with crescentic posterior margin; SB more than 25μ 22

21. Sensillae with basally expanded leaf-like setules obscuring most of the shaft; on bats, North America ..... *Speleocola* Lipovsky

Sensillae nude flagelliform, with 2–4 long branches, or normally barbed .. subgenus *Trombiculla*, in part (*punieri*-group etc.)

22. Scutum sharply pentagonal and fairly small (AW less than 55μ, AP more than 20μ); anterior eyes and sensillary bases subequal; claw 2-pronged, tarsala I long, half length of tarsus, may reach subterminala, with microtarsala I distally about half way along its length; tarsala II distinctly shorter than tarsala I, subcylindrical but without bulbous tips, tarsus III less than 55μ; mastitarsala III present or represented by seta with few barbs *Ellanella* n.subgen., p. 42

Scutum subpentagonal or with crescentic posterior margin*, larger (AW more than 60μ, AP more than 2μ); anterior eye ×2 or more diameter of sensillary bases; claw with 2 or 3 prongs; tarsala I not long, less than a third to a quarter tarsus, with microtarsala nearly level with its tip; tarsala II slightly shorter to much longer than tarsala I; tarsus III over 60μ; mastitarsala III usually present 23

23. Claw 3-pronged (exceptionally 2-pronged, the accessory prong being external); scutum subpentagonal or with crescentic posterior margin; tarsala II narrow and cylindrical, not subconical like tarsala I, and either subequal to or exceeding it in length; tip of tarsala II usually blunt, expanded, frequently bulbous; so far recorded only from African reptiles *Eutr. lawrencei* group, sensu lato, p. 31

Claw 2-pronged, with accessory prong distinct and external; scutum with crescentic posterior margin; both tarsalae subconical and short, tarsala II shorter than tarsala I; so far recorded only from reptiles in Oriental and Australasian regions *Eutr. fieldi* group, **new group**, p. 38

24. Genualae II and III absent, subterminala and parasubterminala I present, terminala I absent. [Nymphs unknown] ..... subgenus *Euschöngastoides* Loomis

Genualae II and III present, subterminala and parasubterminala I present. [Nymphs, where known, are without eyes] 25

25. Leg III, or other legs, with some long outstanding setae 26

All legs with subequal barbed setae 27

26.† Sensillae with few (1–3) barbs or branches, galeal seta B or N, palpal formula N,N,NNN, claw 3-pronged; long outstanding nude or almost nude setae on telofemur, genu, tibia and possibly tarsus of leg III ..... *T. flagellifera* group, **new group** (*T. flagellifera*, *T. tahana* Traub & Audy)

Sensillae normally barbed, galeal seta N, palpal formula B,B,NNB, claw 2-pronged; all legs with short and long finely plumose setae, legs II and III with a number of long outstanding finely feathered setae (cf. many *Neotrombicula*), as long as or longer than tarsus III *T. subquadrata* Lawr., **new group**, monotypic

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* In the subpentagonal scuta, ratio AW/SB is more than 2·4 and SB/ASB less than 1·2; those with crescentic posterior margins are generally broader, with AW/SB less than 2·4 and SB/ASB over 1·2.

† Vercammen-Grandjean (personal communication) has placed *T. flagellifera* and some new species in a new subgenus to be described. *T. subquadrata* clearly belongs to this same subgenus, and the present writer would include in it those species with a barbed galeal seta although Vercammen-Grandjean so far confines his subgenus to species with a nude galeal seta.

27. Anterior eyes prominent, chitinized and large (×3 or more diameter of SB), palpal setae prominent, strongly developed and at least those on femur and genu strongly plumose or pectinate; galeal seta N; possibly primarily parasitic on birds, secondarily on mammals. [Nymphs with both short and long exaggerated dorsal setae, without eyes] .. *Vercana* n.subgen., p. 51

Anterior eye and palpal setae normally developed; usually parasitic on mammals. [Nymphs and adults, where known, are without eyes] 28

28. Galeal seta N; scutum either subquadrate or trapezoidal, SB under 25μ, with SBs close to posterior margin but anterior to line of PLs; palpi N.N.NNN; frequently parasitic on bats subgenus *Trombicula*, in part (e.g. *T. insolli*), *T. levei* group, and species of *Trombicula* of uncertain status.

Galeal seta B (exceptionally N?); scutum subrectangular, SB usually over 25μ, SBs anterior or posterior to line of PLs; palpi usually N.N.BNN(B) .... subgenus *Leptotrombidium* Nagayo *et al.* and species of *Trombicula* of uncertain status.

Further Records and Taxonomic Notes

1. Genus **Trombicula** Berlese, subgenus **Leptotrombidium** Nagayo *et al.*, *sensu lato*.

Trombicula (Leptotrombidium) deliensis Walch, 1922

This species, a vector of scrub typhus, is extremely widespread and has a very wide host-range. Certain ground-birds are important hosts of this species and its close relative *T. akamushi*: they are of epidemiological importance in some foci because they boost the local mite-population, and also generally because they may carry chiggers over considerable distances. In this respect, the importance of the two cuculids *Centropus javanicus* and *Rhinortha chlorophoea* in Sumatra was stressed by Walch & Keukenschrijver (1924). *Trombicula deliensis* has been recorded in our collections from a Rail and a Crake, and the Button- and Bustard-Quails, but not in significant numbers.

Trombicula (Leptotrombidium) akamushi Brumpt, 1910

This species, also a vector of scrub-typhus, is for practical purposes confined in Malaya to the field-rat, *Rattus argentiventer*, in open grassland, and certain ground-birds which frequent such grassland. On these hosts it may occur in very large numbers. The overall infestation rate for *R. argentiventer* trapped in Selangor is about 60 per rat: the only other mammal to carry significant numbers is the wood-rat, *R. jalorensis*, on the grass-scrub fringe, with an average of 10 *akamushi* per rat. Our birds have been collected from sites known to be heavily infested and some of these carry enormous numbers: 9 Button-Quail from a grass-grown subsoil drainage bay on the outskirts of Kuala Lumpur, trapped in May 1949, carried what was estimated to be 18,500 *akamushi*. One of these birds had perhaps 11,000 of these mites. Of 31 quail (of both species) from infested areas, all were found infested and the average was 790 *akamushi* per bird if the one carrying 11,000 is excluded. Ninety *R. argentiventer* from the infested area in Kuala Lumpur carried an average of 133 *akamushi* each, but because of marked variations in infestation rates associated with the weather this figure is not properly comparable with that of the quail. The record of one *akamushi* larva from a skink (p. 71) raises the question as to advisability of recording such stragglers in checklists without comment: the point is discussed on page 74.

2. Genus **Trombicula**, subgenus **Vorcana** (p. 51 above)

Trombicula (Vorcana) vorca Traub & Audy, 1954

Comments.—This species, and the form very close to it from Beaufort, North Borneo, occurring on birds, may be fairly widely distributed by them. The form at Beaufort was very common. Although no species in this group has been recorded from Malaya, a representative may be expected to occur, possibly on birds from the zoogeographically distinct area in the north of Malaya. (*See postscript on p. 78*).

3. Genus **Eutrombicula**, subgenus **Eutrombicula** Ewing (see p. 31)

Eutrombicula (Eutrombicula) wichmanni (Oudemans, 1905)

This species has a wide geographic range, extending to Formosa, Australia, and the Indian region. It also has a wide host range including man: it is a scrub-itch chigger very closely related to the North American pest chigger *E. (E.) alfreddugesi* (= *T. irritans* of authors). Its primary hosts are reptiles, represented in Malaya by skinks and probably monitor lizards, but it also attacks birds, including domestic fowl. On skinks, it appears to produce no particular reaction, but on birds it tends to feed in clusters which produce fairly deep ulcers with rolled edges. On domestic fowl in Kuala Lumpur, *Neoschöngastia gallinarum* is often found in these ulcers accompanying the *wichmanni*. The most important host is the common skink *Mabuya multifasciata*, on which there may be found two chiggers feeding under a single scale. *E. wichmanni* has also been found on snakes and occasionally in the ears of rats outside the forest (especially *R. jalorensis* on the grass-scrub fringe). This species does not appear to occur in large numbers in Malaya and is not as important as a scrub-itch pest as it is in other parts. The Malay name *tungau* doubtless applies to *wichmanni*, and possibly also to *Blankaartia acuscutellaris* which is known to attack man occasionally.

4. The **Babiangia** generic complex

Representative Genera.—This complex comprises three groups which appear to be closely related: the genera *Babiangia* Southcott 1954, sensu lato (see p. 46 above), *Siseca* (p. 41), and *Novotrombicula* Womersley & Kohls, 1947.

Description of Main Characters.—Scutum large (AW over 65μ), deep, closely punctuate all over, and extended posteriorly beyond line of posterolateral setae. Sensillary bases characteristically placed wide apart and relatively close to anterolateral setae, ratios PSB/ASB and SB/ASB being 1·6 to over 3 (both these ratios are under 1·6 in most trombiculids), and ratio AW/SB 1·3 to 1·8 (about 2 or more in most trombiculids). Galeal seta nude. Cheliceral blades curved. Palpal claw 2-pronged, accessory prong being strong, external. Gnathobase, coxae and legs clearly punctate or striate-punctate. Three genualae-I present; mastitarsala-III present or absent. Empodia of all legs thickened, blade-like or claw-like, and may be more developed than the claws.

Comments.—In addition to the characters noted above, the gnathosome is anteriorly placed and the palps tend to arise well forward, giving a trombid-like general appearance to the mouthparts. This is most developed in *Babiangia*. The setae on the fused coxae of the gnathobase tend to be on a level anterior to coxae I, and may be well in advance of it. *Trombicula parmifera* and a new species (*booliati*, p. 46) are here considered to be species of *Babiangia*, sensu lato. *Novotrombicula* is clearly derived from a common stem with the other members of this complex and we may reasonably expect the primary hosts of *Novotrombicula*, when these are found, to be reptiles or

even arthropods. The empodia of *Novotrombicula* have not been re-examined: they may or may not be blade-like or thickened. *Novotrombicula* is distinguished by the additional scutal setae (cf. scuta of *Heaslipia* and *Gahrliepia*) and elongate chelicers. The dorsal setae of *Novotrombicula* are placed in longitudinal rows, to be found also in *Bahiangia bulbifera* and *Gahrliepia (Schöngastiella) aroma* and *G. (S.) birella* Traub & Evans, 1954; the palpal formula is B.B.NNB and mastitarsala-III is absent.

4.1 Genus **Siseca** (see p. 41)

Siseca rara (Walch)

Trombicula rara Walch, 1923:593, 1924, 1925; Walch & Keukenschrijver, 1924; Stiles & Hassal, 1927; Gunther, 1941, 1952:17; Womersley & Heaslip, 1943:90; Blake, *et. al.*, 1945; Kohls, *et al.*, 1945:381; Philip & Woodward, 1946; Finnegan, 1945; Radford, 1946; Audy, 1945:143.

Trombicula (Eutrombicula) rara, Thor & Willman, 1947; Philip & Woodward, 1946.

Trombicula (Trombicula) rara, Wharton & Fuller, 1952:69.

Trombicula (Neotrombicula) rara, Womersley, 1952:80 in part.

Trombicula (*rara*-group) *rara*, Audy, 1954:148.

Neotrombicula rara, Radford, 1954:259.

Comments.—This species was confused with *S. subrara*, a new species from pill-millipedes described on p. 42, in the monograph by Womersley (1952:80, 355). The error was discovered by comparison of nymphs of the two species, too late for amendment of the text except for the corrigendum on his p. 427 substituting the correct standard measurements for *rara*. *Siseca rara* and the nymphs of *rara* and *subrara* are being described fully, and detailed corrigenda made to the 1952 monograph, in a paper by Womersley & Audy, to be published.

Hosts.—This species was described from man (3 or 4 specimens) in Sumatra. Its range extends to New Guinea and it is primarily a reptile-chigger, apparently especially on skinks, but will feed on mammals (nymphs have been reared from larvae taken from rats). In Malaya, *S. rara* is commonest on skinks in forest, especially *Mabuya multifasciata*, scattered about under the scales and mixed with specimens of *E. (E.) wichmanni* and *Bahiangia parmifera*. The list on p. 71 shows the incidence on skinks. It also occurs occasionally in small numbers in the ears of squirrels, rats, and tree-shrews, which should be regarded as casual hosts. The single specimen collected on an island off New Guinea, mentioned by Womersley on his p. 82, might be a distinct species; while Dr. Southcott (personal communication) considers that the 3 specimens recorded (Womersley, p. 81) from *Lygosoma* from Queensland are a new species near *rara*.

4.2 Genus **Bahiangia** Southcott (see p. 46)

Bahiangia parmifera (Womersley)

Trombicula parmifera, Womersley, 1952:109, 2c (corrigendum).

Partial Redescription.—The following details may be added to the published description. The whole *gnathosome* is extended anteriorly, as in *B. bulbifera* and to much lesser extent in *B. hooliati*, and the setae of the fused coxae of the gnathobase are

anterior to coxae I and the trochanters. Chelicer strongly curved. The *palpal formula* is N.N.NNN, all setae subequal, the femoral seta being least developed, the others having strong bases and rapidly tapering to attenuated tips; the seta on the genu is immediately posterior and adjacent to the lateral tibial seta; the palpal tarsus has a cylindrical basal tarsala which is shorter than the subapical terminala, and 6 barbed setae of which 4 are strong and pectinate; claw (13μ) 2-pronged, strong, with a strongly developed dorsal accessory prong. *Legs:* The coxae have 1 seta each, that on coxa I being notably long, and that on coxa III having a heavily chitinized swollen base (resembling the ant-inhabited thorns of some Acacias), the rest of the shaft tapering and bearing a few barbs (fig. 8). The general chaetotaxy does not differ significantly from that of *B. booliati*. Mastitarsala-III is absent. The dimensions of tarsi plus pretarsi and of the tarsalae are as follows: tarsus I 77 $\times$ 22μ, tarsala-I 22μ; tarsus II 59μ, tarsala-II 14μ; tarsus III 72 $\times$ 17μ. Empodia thickened, stronger and more blade-like than the claws. *Body setae:* the ventral setae have expanded bases, resembling the seta on coxa III, and also resembling the ventral setae of *B. bulbifera*.

Both nymph and adult of this species have been reared in this laboratory. They are eyeless and the sensillae have spiculate shafts proximally and a number of barbs or branches in the distal half.

Hosts.—B. parmifera in our collections is confined to skinks (see p. 73) the most important host being the common *Mabuya multifasciata*. Individual skinks may carry 200–300 larvae of *parmifera*, but the average is 30–40 per skink from our collection areas in Selangor. These larvae are easily detached from under scales in the flanks, venter, and legs. They occur in small groups or scattered, only one per scale (unlike *E. wichmanni* which although not so numerous may be found in pairs under one scale), perhaps because the hind quarters of fully engorged larvae project from under the scale. Mixed infestations with *S. rara* and/or *E. wichmanni* are not uncommon.

5. The **Blankaartia** generic complex

Representative Genera.—This complex comprises the two genera *Blankaartia* Oudemans, 1911* (= *Trägardhula* Berlese, 1912; = *Pentagonella* Sig Thor, 1936; = *Megatrombicula* Michener, 1946) and *Hexalipia* Ewing 1944.

The question of including *Neotrombicula* Hirst (1915) in this complex has been discussed above (p. 54). No member of this subgenus (or genus) has been found in Malaysia although species are known from North India, North Borneo and Australia.

* *Blankaartia* Ouds., 1911 v. *Trägardhula* Berl., 1912. The correct name for this genus is a subject of controversy on which the International Commission on Zoological Nomenclature is currently being invited to adjudicate. At the time the present paper went to press, the name *Blankaartia* was acceptable, firstly because Fuller & Wharton (1951) had given reasons for its acceptance in place of *Tragardhula*, showing in their text that they had made an approach to the Commission on at least one point, secondly because no discussion or criticism of this decision had been published in the succeeding four years, and thirdly because *Blankaartia* had been used (as a subgenus of *Trombicula*) by Wharton & Fuller (1952) in their *Manual of the Chiggers*, which is the most complete and authoritative account of World Trombiculids and contains the only fully documented and authoritative Checklist of chiggers. The whole question is however now being taken up by the Commission anew and the result cannot be foreseen because both the strict application of the Rules and the risk of causing considerable confusion must be considered. The present situation arises out of the fact that *Trägardh* in 1904 described *Trombidium nilotieum* on the basis of trombiculid adults and trombidiid larvae found in chance association, so that his species would now be regarded as based on a set of syntypes including two unrelated species. Subsequent authorities have dealt with these syntypes in a confusing manner and a summary of this may be found in papers by Womersley (1948, *Trans. Roy. Soc. S. Aust.*, 72, 83–90) and Fuller & Wharton (1951, *Psyche*, 58, 85–88). Womersley (1952) in his monograph uses *Trägardhula* but does not discuss this usage which is of course based on his earlier paper.

Description of Main Characters.—Larvae: Strongly chitinized chiggers with well-developed and heavily barbed setae on body and scutum. Scutum, gnathobase, cheliceral base, coxae, and legs with numerous deep puncta, and at least some of these striate-punctate. Scutum subpentagonal with deep and rounded posterior margin. Eyes 2+2 on ocular plates. Palpal formula generally B.B.NNB with femoral seta plumose and all setae well developed; palpal claw 3-pronged, with dorsoexternal and ventroexternal accessory prongs. Legs 7-segmented, ordinary setae strong, more or less subequal, and pectinate. Posterior seta on basifemur I more slender and more lightly barbed than the others. Tarsalae I and II small; 3 genualae on leg I, mastitarsala present on leg III. Larvae apparently swamp- or water-frequenting, particularly parasitizing water-birds but also on mammals. *Nymphs and Adults* with sensillary area fairly narrow relative to length of crista, and simple whip-like sensillae. Eyes present, placed away from scutum on each side of the crista, not close to the sensillary bases.

Comments.—Blankaartia was regarded as a subgenus by Wharton & Fuller (1952) and this was followed by Audy (1954). Womersley (1948, 1952) has dealt with it as a genus under the synonym *Trägardhula*, but he has included in it a number of larvae which are in fact *Neotrombicula*. *Blankaartia* is treated as a genus in the present paper for reasons discussed below in connexion with *Fonsecia* by Audy (1954) who also thought that *Blankaartia* might have developed by its special habitat adaptations from a *Neotrombicula* stem.

The genus *Heaslipia* is now included in this complex following the discovery by P. H. Vercammen-Grandjean in the Belgian Congo of two typical species of *Heaslipia*, which he reared to the nymphs. One of these species was almost indistinguishable from *gateri*, and the hosts of both were water-birds. The nymphs have distinct eyes. *Heaslipia gateri* has since (1955) been rediscovered in Malaya and nymphs have been reared. The absence of eyes in the nymphs reported by Womersley (1952:422) must be ascribed to incomplete or wrongly identified material; his text and figures (both 113F & 116P) will require emendation accordingly. The scuta of any of the adults of *Blankaartia* figured by Womersley would suffice for a rough approximation of the scutum of *Heaslipia*. A joint study of the African and Malayan material is to be published shortly (Vercammen-Grandjean, Audy, & Womersley): the present writer is grateful to Vercammen-Grandjean for allowing his important findings in Africa to be noted here.

In our Malayan collections, *B. acustellaris* appears to be associated with rice-fields which are annually flooded, and we have collected it from the rice-field rat, *R. argentiventer*, in such localities. It has also been recorded (by Gater, 1932:148) as attacking man in a rice-field near Kuala Lumpur. In Ceylon and the Maldive Islands, this species is quite clearly associated with swamps and water-plants (Jayewickreme & Niles, 1946; Radford, 1946). In all these areas, no birds have been searched for chiggers. The Malayan collections have been scanty and they are probably casual. *Heaslipia gateri* was collected in small numbers from *R. argentiventer* in rice-fields in Perak, in conditions exactly similar to those of the *acusctellaris* collections, while both *gateri* and *acusctellaris* have recently been found together repeatedly on *R. argentiventer* from rice-fields near Sungei Patani, Kedah. Appearances therefore suggest, by analogy, that the Malayan collections of *B. acusctellaris* and *H. gateri* from rice-field rats may have been from casual hosts, and that water-birds are likely to be important hosts of both these species. *H. gateri* has also been recorded from rats in a restricted area in the Philippines (Philip & Woodward, 1946) but no details were reported. (*See postscript on p. 78*).

The larvae of species of *Heaslipia* and *Blankaartia* examined by the writer resemble each other very closely indeed and differ in only one significant feature, the presence in *Heaslipia* of extra scutal setae (which in this case might not be of generic importance). Nor can any significant differences be found between the nymphs. It would probably be reasonable to regard *Heaslipia* as only a subgenus of *Blankaartia*.

Blankaartia acuscutellaris (Walch)

Trombicula acuscutellaris Walch, 1922:36; Gun., 1952:17.

Trägardhula acuscutellaris, Womersley, 1948:85, 1952:24; 316; Radford, 1954: 262.

Trombicula (Blankaartia) acuscutellaris, Wharton & Fuller, 1952:43 (full references and synonymy).

Heaslipia gateri (Womersley & Heaslip)

Trombiculoides gateri Womersley & Heaslip, 1943:101.

Heaslipia gateri, Ewing, 1944:103; Wharton & Fuller, 1952:83 (full references); Gun., 1952:37; Rad., 1954:262.

These two species have been recorded in Malaya only from rats in or near rice-fields. Evidence outlined above suggests that important hosts may be water-birds or other birds frequenting rice-fields.

6. Genus **Euschöngastia** Ewing, 1938

6.1 **Euschöngastia**, subgenus **Walchiella** Fuller, 1952

Euschöngastia (Walchiella) oudemansi (Walch)

Trombicula oudemansi Walch, 1922:35.

Schöngastia oudemansi, Gater, 1932:154; Gun., 1952:23; Rad., 1954:267.

Schöngastia (Schöngastia) oudemansi, Womersley, 1952:152, 380.

Walchiella oudemansi, Fuller, 1952:220, Wharton & Fuller, 1952:95 (full references and synonymy in both these monographs).

Euschöngastia (Walchiella) oudemansi, Audy, 1954:153 (taxonomy).

Hosts.—There is a single casual record of this species on a reptile: 7 larvae on a monitor lizard (*Varanus salvator*) from a forest reserve in Selangor (see list on p. 70).

Comments.—This common species is a dominant chigger on ground-living mammals, especially the giant-rats *R. müllleri* and *R. bowersi* (average 25 and 19 per rat respectively). It also occurs on the semi-arboreal tree-shrews (average 4 per tree-shrew), and the tree-rat *R. canus* (average 11 per rat). It is very rarely found on tree-living animals other than *R. canus* and appearances suggest that it may infest certain types of nest or burrow. It was originally recorded from man in Sumatra. The record of this species on a monitor must be regarded as exceptional and possibly derived from an abandoned (or shared) burrow.

Walchiella was placed by Fuller and by Wharton as a monotypic genus in the Gahrliepiinae on account of its 7–6–6 leg-segmentation. It was placed by Traub & Audy, 1954b:77 and Audy, 1954:153 in the Trombiculinae as a subgenus of *Euschöngastia* because of the very close relationships between larvae and nymphs of a number of

undescribed species of *Walchiella* and larvae and nymphs of a typically Trombiculine group, the *lacunosa*-group. *Walchiella* can now be seen to share no characters with gahrliepiine species other than the 7–6–6 leg-segmentation in the larvae. *Euschöngastia* is however probably only a temporary respository and for reasons discussed under *Fonsecia* (Audy 1954:48) *Walchiella* may well be recognized as a genus (though not gahrliepiine) in which case the *lacunosa*-group and possibly the *similis*-group should go with it. Two characters which have not hitherto been recognized are shared by *Walchiella* and the *lacunosa* group, viz., the presence of flanges on the bases of the chelicers (hard to see in old mounts), and an incomplete fusion of the coxae of the gnathobase, showing as a chitinous break or thinning in the midline. These features are not shared by the otherwise similar *similis-smithi-perameles*-group which has hitherto been confused with the *lacunosa*-group. A revision of the three groups is in progress in collaboration with Robert Domrow.

6.2 **Euschöngastia**, subgenus **Laurentella** Audy, 1956

Euschöngastia (Laurentella) indica (Hirst)

Euschöngastia indica (Hirst, 1915:187); Wharton & Fuller, 1952:77.

Euschöngastia sp. near *E. indica*, from millipede, Audy, 1950.

Euschöngastia (Laurentella) indica, Audy, 1956:7 (this *Bulletin*).

Neoschöngastia indica, Gun., 1952:26.

Arthropod Host.—A single larva of the common chigger *indica* was found attached to a pill-millipede from forest in Selangor on two separate occasions (see p. 71, 75), accompanied each time by large numbers of the host-specific *S. subrara*. This must be regarded as an exceptional and casual infestation, probably derived from a rat's nest.

Euschöngastia (Laurentella) species

Most species of *Laurentella* appear to pertain to forest mammals, especially rodents. Casual infestation of birds must however be expected. *E. (L.) daria* Traub & Audy, 1954b was recorded in Borneo on the chick of a ground-bird. It is noteworthy that the species *E. (L.) audyi* (Womersley, 1952), which is a dominant chigger on all forest canopy mammals, has not been recorded on any of the tree-living birds in our collection (p. 72). This tends to support the supposition that *audyi* infests the nests of its hosts and would therefore have little contact with birds.

7. Genus **Neoschöngastia** Ewing, 1929

This genus appears to pertain essentially to birds. The submergence of the scutum which is considered characteristic of this group might have developed also in unrelated groups and the characters of this heterogenous genus require much further study. The failure to find a single specimen of *Neoschöngastia* on all the birds examined recently in Malaya (p. 72) is interesting and the matter is being followed up.

Neoschöngastia gallinarum (Hatori)

Neoschöngastia gallinarum (Hatori, 1920:347); Wharton & Fuller, 1952:85 (full references); Womersley, 1952:252, 390 (including nymph); Gun., 1952:27.

This species occurs in small numbers, accompanying colonies of *E. wichmanni* in ulcers on the skin of domestic fowl in Kuala Lumpur (Institute grounds). It has been recorded from a kingfisher, nightjar, crow-pheasant, crow, tree-sparrow, and domestic fowl in Formosa.

Neoschöngastia riversi Wharton & Hardcastle

Neoschöngastia riversi Wharton & Hardcastle, 1946:298; Wharton & Fuller, 1952:86 (full references); Womersley, 1952:271; Gun., 1952:34.

This species has been found twice in Malaya: 18 and 8 larvae on the wing-membranes of flying lizards (*Draco fimbriatus* and *D. maximus*) from a forest reserve in Selangor, both times in company with *E. tweediei* (see p. 70). The only other record of a *Neoschöngastia* on a reptile is that of the widespread *N. americana* on a lizard (*Sceloporus*) in Texas. The discovery of another bird-chigger on flying lizards in Malaya is particularly whimsical.

8. Larval Trombidiidae, simulating Apoloniinae, on Arthropods

In a preliminary note (Audy, 1950) on the occurrence of trombiculids on arthropods, the writer recorded the following: (*a*) "*Trombicula rara*" on pill-millipedes—this is now described as *Siseca subrara* (p. 42); (*b*) *Euschöngastia* species near *indica* from a millipede—this is now confirmed as *E. (L.) indica* (p. 64) and a second straggler has since been found; (*c*) "*Trombicula* (or *?Tragardiula*) sp. indet." from a scorpion—this is here described as *Entrombicula eltoni* (p. 33); and (*d*) "*Womersleyia* sp. . . . and other leeuwenhoekiid larvae" from various arthropods. Two of these last named species have since been described by Womersley as being close to Apoloniinae in the larval stage, although in fact one is certainly, and the other almost certainly, not apoloniine (or leeuwenhoekiid in the sense of Womersley), but trombidiid. These two species, each in a monotypic genus, are *Cockingsia tenuipes* Wom., 1954:117, from the basal wing-veins of a giant longicorn beetle, and *Audyana thompsoni* Wom., 1954:118, subfamily Trombellinae, from the venter of the Malayan scorpion *Heterometrus longimanus*.

Lists of Infested and Uninfested Hosts examined for Trombiculids in Malaya

The following hosts (835 reptiles, 738 birds, 212 myriapods, 22 arachnids) have been examined for trombiculids up to the end of September 1955 (birds up to the end of August 1955). Most of the birds have been collected between April and August 1955 in connexion with studies on Japanese encephalitis. Identifications of reptiles have been made by Mr. Lim Boo-Liat and checked by Mr. J. L. Harrison and in doubtful cases by Mr. M. W. F. Tweedie; nearly all the birds have been identified by Mr. Lim in Mr. Harrison's absence on leave, and doubtful identifications as well as the first reference specimens have been checked by Dr. C. Gibson-Hill and Dr. B. D. Molesworth. A reference collection of flat bird-skins has been built up in this laboratory and identifications have kindly been checked by Dr. Gibson-Hill.

The authorities taken for the scientific and popular named of hosts are as follows:—

Snakes : Tweedie (1953).

Lizards: Smith (1930).

Birds : Gibson-Hill (1949) (whose serial numbers are quoted).

Numbers prefixed by 'R' are serial numbers in the register of the Zoology Laboratory (Colonial Office Research Unit), Institute for Medical Research.

Birds†

Total examined: 738, of *ca.* 70 species

Order Hemipodii

TURNICIDAE, Bustard-Quail (19, of 1 species)

19 *Turnix suscitator atrogularis* (91a, Barred Bustard-Quail).

18 with *ca.* 7,800 **T. akamushi**, *ca.* 120 **T. deliensis**, Seaport Estate and Kuala Lumpur area.

R.14998 with 89 **E. wichmanni** only, Ulu Langat, v.1951.

Order Gralleae

RALLIDAE, Rails (6, of 3–4 species)

2 *Amaurornis phoenicurus chinensis* (100a, Whitebreasted Water-Hen).

*1 *Poliolimnas c. cinereus* (99, Greybellied Crake).
R.7298 with 9 **T. akamushi**, 3 **T. deliensis**, West Folly, K.L. area, vii.1949.

1 *Rallus striatus gularis* (93, Slatybreasted Rail).
R.8200 with 25 **T. akamushi**, nr. Port Dickson, 6.x.1949.

2 Rails, unidentified.
R.2675 with 25 **T. akamushi**, 39 **T. deliensis**, S. Buloh, 5.vii.1948.

*R.37072 with ca. 550 **T. akamushi**, West Folly, K.L. area, 18.vi.1954.

Order Accipitres

ACCIPITRIDAE, Hawkes, Eagles, Vultures (1)

1 *Machaerhamphus a. alcinus* (43, Bat Hawk).

Order Gallinae

PHASIANIDAE, Game birds (30, of 5 species)

19 *Excalfactoria c. chinensis* (78, Bluebreasted Button-Quail).

*17 with *ca.* 27,000 **T. akamushi**, West Folly, K.L. area, v.xii.1949.

1 ex 2 with **T. akamushi**, nr. Port Dickson, x.1949.

1 *Rhizothera l. longirostris* (76, Longbilled Partridge).

1 *Rollulus roulroul* (82, Crested Green Wood Partridge).

1 *Argusianus a. argus* (89, Argus Pheasant).

8 *Gallus gallus domesticus* (Domestic Fowl).

5 with 115 **E. wichmanni**, & 2 with 8 **Neoschöngastia gallinarum**, I.M.R. grounds, Kuala Lumpur, 8.x.1949.

2 with 470 **E. wichmanni**, Kuala Lumpur, 14.ix.1954.

Order Charadriiformes

SCOLOPACIDAE, Sandpipers, Snipe (26, of 1 species)

26 *Capella stenura* (132, Pintail Snipe).

Order Columbae

COLUMBIDAE, Pigeons, Doves (1)

1 *Chalcophaps i. indica* (177, Emerald Dove).

† The numbers in parenthesis refer to numbers in Gibson-Hill's checklist, repeated by Glenister (1951).

* Those marked with an asterisk were collected in same area (West Folly, off Kuala Lumpur Gardens) as the heavily infested Quail.

Order CORACIIFORMES

CUCULIDAE, Cuckoos, Malkohas (6, of 4 species)
2 *Rhinortha chlorophaea* (201 Raffle's Malkoha).
2 *Centropus sinensis eurycercus* (205b, Large Crow-Pheasant).
R.6149 with 44 **T. akamushi**, S. Buloh, 29.iv.1949.
*1 *Centropus bengalensis javanensis* (206, Lesser Crow-Pheasant).
1 *Rhopodytes s. sumatranus* (199, Rufousbellied Malkoha).

ALCEDINIDAE, Kingfisher (1)
1 *Halcyon smyrnensis fusca* (259, Whitebreasted Kingfisher).
R.14530, with 1 **E. wichmanni**, S. Buloh, iv.51.

TYTONIDAE, Barn Owls (1)
1 *Phodilus b. badius* (208, Bay Owl).

STRIGIDAE, Owls (2, of 1 species)
2 *Otus bakkamoena lempiji* (213, Collared Scops Owls).

CAPRIMULGIDAE, Nightjar (1)
1 *Caprimulgus macrurus himaculatus* (229, Long-tailed Nightjar).

APODIDAE, Swifts, Swiftlets (2, of 1 species)
2 *Apus affinis subfurcatus* (240, House-Swift).

MEROPIDAE, Bee-eaters (28 of 1 species)
28 *Merops v. viridis* (265, Bluethroated Bee-eater).

BUCEROTIDAE, Hornbill (1)
1 *Berenicornis comatus* (270, Long-crested Hornbill).

PICIDAE, Woodpeckers, Piculets, (3, of 3 species)
1 *Micropternus brachyurus squamigularis* (295, Rufous Woodpecker).
1 *Dinopium j. javanense* (304, Goldenbacked Threetoed Woodpecker).
1 *Hemicircus concretus sordidus* (313, Grey-and-Buff Woodpecker).

Order PASSERES

EURYLAIMIDAE, Broadbills (3, of 2 species)
2 *Calyptomena v. viridis* (318, Green Broadbill).
1 *Eurylaimus o. ochromalus* (322, Black-and-Yellow Broadbill).

TIMALIIDAE, Babblers (48, of 12 species)
1 *Pellorneum capistratum nigrocapitatum* (368, Blackcapped Babbler).
5 *Malacocincla m. malaccensis* (370, Shorttailed Babbler).
2 *Malacocincla abbotti oliveum* (374, Common Brown Babbler).
5 *Malacopteron c. cinereum* (376, Lesser Redheaded Tree Babbler).
4 *Malacopteron m. magnirostre* (377, Brownheaded Tree Babbler).
1 *Pomatorhinus montanus occidentalis* (380, Chestnutbacked Scimitar Babbler).
3 *Macronus g. gularis* (388, Yellowbreasted Tit Babbler).
2 *Macronus p. ptilosus* (389, Fluffyhacked Babbler).
11 *Stachyris p. poliocephala* (391, Greyheaded Tree Babbler).
6 *Stachyris maculata pectoralis* (394, Redrumped Tree Babbler).
4 *Stachyris e. erythroptera* (395, Redwinged Tree Babbler).
4 *Yuhina zantholeuca interposita* (410, Whitebellied Crested Babbler).

AEGITHINIDAE (IRENIDAE) Loras, Leafbirds (3, of 1 species)
3 *Irena puella malayensis* (420, Fairy Bluebird).

* One collected from West Folly.

PYCNONOTIDAE, *Bulbuls* (395, of 13 species)
- 58 *Pycnonotus* spp. indet. (Bulbuls).
- 13 *Pycnonotus a. atriceps* (423, Blackheaded Bulbul).
- 7 *Pycnonotus dispar caecilii* (424 Blackcrested Yellow Bulbul).
- 7 *Pycnonotus squamatus webberi* (425 Scalybreasted Bulbul).
- *67 *Pycnonotus goiavier personatus* (431, Yellowvented Bulbul).
- 120 *Pycnonotus b. brunneus* (434, Redeyed Brown Bulbul).
- 9 *Pycnonotus s. simplex* (435, White-eyed Brown Bulbul).
- 66 *Pycnonotus e. erythropthalmos* (436, Lesser Olive-brown Bulbul).
- 7 *Criniger i. tephrogenys* (437, Scrub Bulbul).
- 8 *Criniger p. phaeocephalus* (439, Whitethroated Bulbul).
- 31 *Tricholestes c. criniger* (441, Hairybacked Bulbul).
- 1 *Microscelis mcclellandi paracensis* (443, Mountain Streaked Bulbul).
- 1 *Microscelis flavalus cinereus* (445, Ashy Bulbul).

TURDIDAE, Thrushes, Robins, Chats (8, of 1 species)
- 8 *Copsychus malabaricus malloperenus* (451, Common Sharma).

SYLVIIDAE, Warblers, Tailorbirds (3, of 2 species)
- 1 *Prinia flaviventris raffesi* (468, Yellowbellied Wren Warbler).
- 2 *Orthotomus sutorius maculicollis* (482, Longtailed Tailorbird).

MUSCICAPIDAE, Flycatchers (7, of 3 species)
- 5 *Rhipidura p. perlata* (486, Spotted Fantailed Flycatcher).
- 1 *Hypothymis azurea prophata* (514, Blacknaped Blue Flycatcher).
- 1 *Terpsiphone paradisi affinis* (515, Resident Paradise Flycatcher).

NECTARINIIDAE, Sunbirds, Spiderhunters (24, of 3 species)
- 5 *Anthreptes s. simplex* (534, Plaincoloured Sunbird).
- 1 *Anthreptes s. singalensis* (538, Rubycheeked Sunbird).
- 18 *Arachnothera l. longirostra* (545, Little Spider-hunter).

DICAEIDAE, Flower-peckers (5, of 2 species)
- 2 *Dicaeum t. trigonostigmum* (554, Orangebellied Flower-pecker).
- 3 *Dicaeum concolor borneanum* (556, Plaincoloured Flower-pecker).

PLOCEIDAE, Sparrows, Munias, Weavers (114, of 7 species)
- 23 *Passer montanus malaccensis* (563, Tree Sparrow).
- 3 *Padda o. oryzivora* (565, Java Sparrow).
- 1 *Munia atricapilla sinensis* (566, Blackheaded Munia).
- 31 *Munia m. maja* (567, Whiteheaded Munia).
- 19 *Munia punctulata fretensis* (568, Spotted Munia).
- 34 *Munia striata subsquamicollis* (569, Sharptailed Munia).
- 3 *Ploceus philippinus infortunatus* (573, Weaver-Finch).

Reptiles (Squamata)

1. Snakes (suborder Serpentes)

Total examined: 275, of 53 species

TYPHLOPIDAE (1, of 1 species)
- 1 *Typhlops brominus* (Common Blind Snake).

XENOPELTIDAE (8, of 1 species)
- 8 *Xenopeltis unicolor* (Iridescent Earth Snake).

* One collected from West Folly.

BOIDAE (20, of 2 species)

10 *Python curtus* (Short Python).
10 *Python reticulatus* (Reticulated Python).

COLUBRIDAE (185, of 38 species)

5 *Acrochordus javanicus* (Elephant's Trunk Snake).
7 *Ahaetulla ahaetulla* (Painted Bronzeback).
5 *Ahaetulla caudolineata* (Striped Bronzeback).
2 *Ahaetulla formosa* (Elegant Bronzeback).
2 *Boiga cynodon* (Dog-toothed Cat Snake).
6 *Boiga dendrophila* (Yellow-ringed Cat Snake, Mangrove Snake).
5 *Boiga drapiezii* (White-spotted Cat Snake).
2 *Boiga jaspidea* (Jasper Cat Snake).
3 *Boiga nigriceps* (Dark-headed Cat Snake).
2 *Calamaria pavimentata* (Collared Reed Snake).
4 *Calamaria vermiformis* (Variable Reed Snake).
9 *Chrysopelea paradisi* (Paradise Tree Snake).
1 *Chrysopelea pelias* (Twin-barred Tree Snake).
1 *Chrysopelea ornata* (Golden Tree Snake).
2 *Dryophiops rubescens* (Keel-bellied Whip Snake).
3 *Dryophis fasciolatus* (Speckled-headed Whip Snake).
7 *Dryophis mycterizans* (Malayan Green Whip Snake).
29 *Dryophis prasinus* (Gross-green Whip Snake).
12 *Elaphe flavolineata* (Common Malayan Racer).
24 *Elaphe oxycephala* (Red-tailed Racer).
10 *Haplopeltura boa* (Blunt-headed Tree Snake).
1 *Homalopsis buccata* (Puff-faced Water Snake).
1 *Liopeltis baliodeirus*
1 *Lycodon aulicus* (Common Wolf Snake, House Snake).
1 *Lycodon effraenis* (Scarce Wolf Snake).
1 *Lycodon subcinctus* (Banded Wolf Snake).
6 *Macropisthodon flaviceps* (Orange-necked Keelback).
4 *Natrix chrysarga* (Speckle-bellied Keelback).
1 *Natrix sanguinea* (Smedley's Keelback).
4 *Natrix trianguligera* (Triangle Keelback).
R.31816 with 3 **F. celestcae**, Bk. Lanjan F.R., 18.iii.1953.
3 *Oligodon octolineatus* (Striped Kukri Snake).
5 *Oligodon purpurascens* (Brown Kukri Snake).
2 *Pseudorhabdion longiceps* (Dwarf Reed Snake).
1 *Psammodynastes pulverulentus* (Mock Viper).
9 *Ptyas korros* (Indochina Rat Snake).
R.13785 with 2 **E. wichmanni**, Ulu Langkat F.R., 16.i.1951.
1 *Sibynophis melanocephalus* (= *S. geminatus*).
1 *Xenelaphis hexagonotus* (Malaysian Brown Snake).
2 *Zaocys fuscus* (White bellied Rat Snake).

ELAPIDAE (31, of 6 species)

2 *Bungarus candidus* (Malayan Krait).
1 *Bungarus flaviceps* (Red-headed Krait).
5 *Maticora bivirgata* (Blue Malaysian Coral Snake).
9 *Maticora intestinalis* (Banded Malaysian Coral Snake).
3 *Naja hannah* (Hamadryad, King Cobra).
11 *Naja naja* (Cobra).

VIPERIDAE (30, of 5 species)

3 *Trimeresurus monticola* (Mountain Pit Viper).
4 *Trimeresurus popeorum* (Pope's Pit Viper).
1 *Trimeresurus purpureomaculatus* (Shore Pit Viper).
5 *Trrimeresurus sumatranus* (Sumatran Pit Viper).
17 *Trimeresurus wagleri* (Wagler's Pit Viper).

2. Lizards (suborder Sauria)

Total examined: 560, of 27 species

GEKKONIDAE, Geckoes (70, of 8 species)

1 *Gonatodes kendalli*.
1 *Gekko gecko* (Tuck-loo, or Tokay; from Jarak Island).
6 *Gekko monarchus* (House Gecko).
29 *Gekko stentor* (Giant Gecko).
14 *Gymnodactylus consobrinus*.
11 *Hemidactylus frenatus* (House Gecko, "chichak").
1 *Cosymbotus platyurus*.
7 *Ptychozoon kuhli* (Flying Gecko).

AGAMIDAE (375, of 9 species)

2 *Draco blanfordi* (Flying Lizard).
R.43044 with 1 **E. tweediei**, Bk. Lagong F.R., 16.ix.1955.
3 *Draco fimbriatus* (Flying Lizard).
R.37516 with 20 **E. tweediei**, 18 **Neoschöngastia riversi**, Bk. Lanjan F.R., 13.viii.1954
4 *Draco maximus* (Flying Lizard).
R.42949 with 5 **E. tweediei***, 8 **N. riversi**, Bk. Lagong F.R., 20.ix.1955.
106 *Draco melanopogon* (Flying Lizard).
R.42824, R.42935, R.42985 with 1 **E. tweediei** each*, Bk. Lagong F.R., 29.vii to 30.ix.1955.
3 *Draco quinquefasciatus* (Flying Lizard).
R.42571 with 1 E. tweediei, Bk. Lagong F.R., 17.viii.1955.
18 *Draco volans* (Common Flying Lizard).
R.35994 with 6 **E. wichmanni**, Bk. Lagong F.R., 24.ii.1954.
R.39502 with 2 **E. tweediei**, 1 **E. fieldi**, Ulu Langat F.R., 15.ii.1955.
18 *Calotes cristatellus* (Green Crested Lizard).
218 *Gonocephalus borneensis*.
3 *Gonocephalus grandis*.

VARANIDAE, Monitors (27, of 75 species)

7 *Varanus dumerilii*.
R.6773 with 25 **E. wichmanni**, Bk. Lagong F.R., 14.vi.1949.
R.14009 with 14 **E. wichmanni**, Ulu Langat F.R., 13.ii.1951.
2 *Varanus flavescens*.
R.14487 with 5 **E. wichmanni**, Sungei Buloh, 6.iv.1951.
5 *Varanus nebulosus*.
3 *Varanus rudicollis*.
9 *Varanus salvator*.
R.6032 with 7 **Euschöngastia (Walchiella) oudemansi**, Bk. Lanjan F.R., 11.iv.1949.
1 *Varanus* sp. indet.

* Not included in type series, p. 38.

SCINCIDAE, Skinks (88, of 5 species)

4 *Lygosoma atrocostatum* (from islands in Malacca Straits).

6 *Lygosoma bowringii* (Common Supple Skink).
R.34861 with 5 **B. parmifera**, S. Buloh, 22.iv.1953.

2 *Lygosoma maculatum*.

3 *Lygosoma olivaceum*.
R.31210 with 6 **S. rara**, 6 **E. fieldi**, Bk. Lanjan, 12.i.1953.

73 *Mabuya multifasciata* (Common Skink or Sun lizard—42 from Selangor, 31 from islands in Malacca Straits):—

	B. parmifera	*S. rara*	*E. (E.) wichmanni*	*Spns. not identified*	*Locality, date*
R.7453 ..	51	2	—	—	B. Lagong, 11.viii.1949.
R.14528 ..	1	2	13	120	S. Buloh, 12.iv.1949.
R.14529 ..	50	7	4	350	S. Buloh, 12.iv.1949.
R.14574 ..	11	2	51	85	U. Langkat, 17.vi.1949.
	plus 3 *B. hooliati*				
R.14588 ..	198	2	1	374	S. Buloh, 17.vi.1949.
R.14685 ..	43	7	14	—	S. Buloh, 1.v.1949.
R.14804 ..	144	15	—	—	S. Buloh, 17.v.1951.
R.14897 ..	47	5	3	—	S. Buloh, 28.v.1951.
R.31608 ..	—	9	—	—	B. Lagong, 20.ii.1953.
	plus 1 *Fan. celestei*				
R.35281 ..	17	4	3	—	B. Lanjan, 14.xii.1953.
R.36942 ..	—	9	—	—	B. Lanjan, 11.vi.1954.
R.37220 ..	28	39	—	—	B. Lanjan, 7.vii.1954.
R.37741 ..	—	36	—	—	B. Lanjan, 6.ix.1954.
R.37805 ..	58	26	—	—	U. Langkat, 10.xi.1954.
R.37959 ..	12	36	—	—	B. Lanjan, 20.xi.1954.
	plus 1 *T. akamushi*				
R.40363 ..	47	26	—	—	B. Lagong, 18.iv.1955.
R.42256 ..	—	8	—	—	B. Lagong, 28.vii.1955.
Totals ..	707	238	89	929 + 5 = 1,968 ex 42 in Selangor.	

Arthropods

Class DIPLOPODA, Order ONISCOMORPHA

SPHAEROTHERIIDAE

212 *Sphaeropaeus globus-magicus* Jeekel (Giant Pill-millipede)—identified for type series only.

Bk. Lagong F.R. (mostly Dusun Wam), 1949–1950: 194 examined, 57 with over 1,500 **S. subrara** and 1 **Euschöngastia indica** (on R.33763, 21.xi.1953).

Gombak F.R. (Pahang Rd): 12 examined, 7 with 75 **S. subrara** and 1 **Eusch. indica** (on R.6777, 14.vi.1949).

Ulu Langat F.R.: 6 examined, 1 with 5 **S. subrara**.

Class ARACHNIDA, Order SCORPIONIDEA

SCORPIONIDAE

22 *Heterometrus longimanus* (Herbst) (Common Giant Black Scorpion).
16 ex Bk. Lagong F.R., iv.1949—xii.1950:
R.7971 with 27 **E. ettoni** (15 larvae, 11 pelts, 12 nymphs), 21.ix.1949.
R.8578 with 1 **E. ettoni,** 28 **Audyana thompsoni,** 9.xi.1949.
Total of 8 with 93 **A. thompsoni** including above.
2 ex Bk. Lanjan F.R. with 20+1 **A. thompsoni,** ix.1949, iv.1950.
2 ex Gombak F.R. (Pahang Rd.), with 20+8 **A. thompsoni,** ii.1949.
2 ex Ulu Langkat F.R. and S. Buloh, uninfested.

SYNOPSIS OF HOST LISTS WITH COMMENTS

Birds

Number examined: 721, of *ca.* 70 species in 52 genera.

Number infested and Trombiculids involved:—

(*a*) 18 of 19 Bustard-Quail *(Turnix)* and 18 of 19 Button-Quail *(Excalfactoria)* with large numbers of the vector *T. akamushi.*

(*b*) A Crake *(Poliolimnas),* several Rails, and a Crow-pheasant *(Centropus)* with considerable numbers of *T. akamushi* and a few *T. deliensis.*

(*c*) Domestic fowl regularly, and quail occasionally, with *E. wichmanni.*

(*d*) Domestic fowl with significant numbers of *Neo. gallinarum.*

Comments on Infestation of Birds

Ground-birds are known to be locally important hosts of the vectors. This is borne out in the case of *T. akamushi* on the two different quails, as well as on rails and crow-pheasants, in Malaya. *T. deliensis* does not appear to be so well supported by birds.

The major hosts of *E. wichmanni* in our collections appear to be skinks (primarily) and domestic fowl (secondarily). Jungle-fowl have unfortunately been neglected. It is worth noting that crow-pheasants collected near Beaufort, North Borneo, by a joint U.S. Army research team were heavily infested by *E. wichmanni* and a species near *T. vorca*; one of these birds was also infested by *Euschöngastia (Helenicula) signata* (Wom.).

The failure to find representatives of the bird-chigger genus *Neoschöngastia* except for *N. gallinarum* on domestic fowl and *N. riversi* on flying-lizards, is probably due to sampling bias: Over 600 birds collected in islands of the Western Pacific area during World War II yielded a considerable number of *Neoschöngastia* of 14 species (Wharton & Hardcastle, 1946, and Wharton, personal communication).

Reptiles

Snakes

Number examined: 283, of 53 species in 29 genera.

Number infested: 2, of 2 species in 2 genera.

Trombiculids: small numbers of *E. wichmanni* and *Fonsecia celesteae* n.sp., the former being a very widespread reptile-chigger and the second being a member of a genus almost restricted to snakes.

Lizards

Number examined: 560, of 27 species in 11 genera.

Number infested:—

(*a*) None of 70 geckoes of 8 species in 5 genera.

(*b*) None of 239 agamids (crested lizards) of 3 species in 2 genera, but 9 of 136 other agamids (flying lizards) of 6 species in 1 genus *(Draco)*.

(*c*) 4 of 27 varanids (monitors) of 5 species in one genus *(Varanus)*.

(*d*) 2 of 15 skinks of 4 species in 1 genus *(Lygosoma)*; and 17 of 42 skinks of 1 species *(Mabuya multifasciata)* from the mainland but none of 31 of the same species from islands of oceanic type in the Malacca Straits.

Trombiculids:—

(*a*) Each species of flying lizard *(Draco)* has been found infested: a total of 9 out of 136 specimens with 32 *E. tweediei* (on all species), 1 *E. fieldi*, 6 *E. wichmanni* and 26 *N. riversi* (on 2 species). *Draco melanopogon* appears to be less freely infested than the other species (106 with only 3 chiggers).

(*b*) 3 varanids with 44 *E. wichmanni*, and a fourth with 7 *Eusch. (Walchiella) oudemansi*.

(*c*) About 40 per cent of the common skink, *M. multifasciata*, from the mainland infested with nearly 50 chiggers per skink (nearly 120 per infested skink) of species *B. parmifera*, *S. rara*, and *E. wichmanni* roughly in the proportions of 7:2:1, plus 3 *B. booliati*, 6 *E. fieldi*, 1 *F. celesteae*, and 1 *T. akamushi* (straggler).

Comments on Infestation of Reptiles

The only groups of reptiles which appear to support specific chiggers are the flying-lizards (*Draco*, Agamidae) and the skinks. The writer's impression is that the richness of the trombiculid fauna parasitic on an animal or a group of animals is related not so much to systematic position as to habits, general population density, and range of geographical distribution. The systematic position of the animal tends to be associated with the systematic position of the chiggers but not particularly with the richness of parasitic species or their numbers. The peculiar distribution of chiggers among the reptiles is likely to have some extremely interesting implications for the biologist.

Eutrombicula (Eutrombicula) wichmanni (which might be regarded as a subspecies of the type of *Eutrombicula*, *E. alfreddugèsi*, of North America) differs from all the other Malayan reptile-chiggers in being very widespread, having a very wide host range and occurring in parts of some countries in large numbers as a pest-chigger. *Siseca rara* also has a wide range but appears to occur in much smaller numbers on animals generally.

Arthropods

Myriapods: giant pill-millipedes, *Sphaeropaeus* (possibly of more than one species)

Number examined: 212.

Number infested by S. subrara: 65.

Arachnids: giant scorpion, *Heterometrus longimanus*

Number examined: 22.

Number infested by E. eltoni: 2.

Comments on infestation of arthropods

The infestation of arthropods by trombiculids is exceptional, and indeed confinement of parasitism to verbebrates was formerly taken as characteristic of the family Trombiculidae, differentiating it from the Trombidiidae and related families which parasitize arthropods and to a lesser extent reptiles. The only trombiculid records known to the writer are:—

Trombicula (Leptotrombidium?) muscae (Oudemans, 1906), Fuller, 1952:91; Wharton & Fuller, 1952:54. This is a bat-chigger which has been collected mostly in Holland, a straggler (the type) being recorded from *Musca domestica*, Buré, France.

Blankaartia (?) pentagona (Wom.) = *Trägardhula pentagona*, Wom., 1952:29: 13 specimens collected on boots, and a single specimen on butterfly, *Troïdes priamus*, in Queensland. From the description of this species, it is near to but not necessarily a *Blankaartia* (*Trägardhula*, synonym).

Acomatacarus (Acomatacarus) paradoxurus (André), Wharton & Fuller, 1952: 99, from a scorpion, *Buthus gibbosus*, in Crete.

Euschöngastia (Laurentella) indica, stragglers on pill-millipedes in Malaya.

Siseca subrara, from pill-millipedes in Malaya.

Eutrombicula (Eltonella) eltoni, from a scorpion in Malaya.

Of these, the last two alone are known to be regularly parasitic on their arthropod hosts, and are presumably more or less host-specific—many rats and skinks have been collected from the same areas as the infested millipedes and scorpions but *subrara* and *eltoni* have never been recorded from other than their arthropod hosts. The records of *B. pentagona*, *T. muscae*, and *E. indica* are almost certainly of stragglers, though the normal host of *pentagona* is unknown; the *A. paradoxurus* on the scorpion might be stragglers or they might not. All these trombiculids except *T. muscae* and *E. indica* belong to groups of reptile-chiggers or groups which include reptile-chiggers. Whether or not this is due to a predilection for cold-blooded creatures, it suggests that the three reptile-chigger groups concerned may stem from primitive stocks.

To the above we may add a new record which is simply a curiosity: two engorged larvae of the vector *T. (L.) deliensis* were found attached symmetrically to the metanotum of a small tipulid fly which flew onto the writer's worktable in a hut at Tinompok, Mt. Kinabalu, North Borneo, on 5.xi.1952 during a joint investigation with the U.S. Army Research Unit. One chigger was mounted, the other disintegrated during an unsuccessful attempt to rear the nymph.

Casual Hosts and Records of Stragglers

Hopkins (1949) is strongly of the opinion that new species of lice should not even be published if they are from single specimens or the host is unknown. The relation between host and louse is close and important, while not only do stragglers occur occasionally by accident in nature but there are considerable risks of cross-contamination on

the worker's bench, or in traps, etc. An important question arising out of some of the records in the present paper is what is to be done about the recording without qualification in checklists of casual hosts which may carry one or a few straggling trombiculids.

Examples may be given illustrating this difficulty. Southcott (1947:450) described lizards in the coastal area of North Queensland as being infested by chiggers which "appeared" to be the "common *Trombicula* there, generally considered as *Trombicula deliensis* . . . " He made it clear that no final identification had been made, though he did suggest that lizards might be of local importance in the epidemiology of scrub typhus and therefore worthy of further study. He did not however publish a firm record, and although both Fuller (1952:38) and Wharton & Fuller (1952:52) referred to the paper they did not record lizards as hosts of *deliensis*; nor did Harrison & Audy (1951). In a personal communication (5.i.1955) for which the writer is very grateful, Southcott states that the chiggers concerned have since been identified by him as mostly *E. (E.) tovelli* (Wom., 1952). Unfortunately, however, he has been misquoted in at least one abstract as stating that *deliensis* has been identified in considerable numbers on lizards. If our records of one *akamushi* on a skink and two *deliensis* on a fly are now advertised it will tend to perpetuate an unfortunate misinterpretation. In a recent checklist of trombiculids (Radford, 1954:259) the reptile-chigger *S. rara* is listed with only the type host, "*Homo sapiens L.*" Although a checklist cannot be expected to summarize data for the ecologist, its value would be enormously increased if it discriminated between regular and exceptional or occasional hosts. The remedy must lie with those who describe and record the species: it is most important to record the hosts examined and *not* found infested as well as those infested. If the worker himself has an opinion as to which are regular and which are casual hosts, then his contribution would be improved by recording this opinion.

The following records in the present paper are considered to be casual, that is, the chiggers are stragglers and these records have an interest which is completely different from that attaching to records of other hosts. As noted above, many records of stragglers are simply curiosities, though their publication should presumably not be suppressed, especially in the case of the habitat-specific trombiculids.

Stragglers on exceptional hosts:—

Trombicula deliensis on a tipulid (p. 74).

Trombicula akamushi on a skink (p. 71).

Eutrombicula wichmanni on man and probably snakes in Selangor (p. 59).

Siseca rara on man (p. 60).

Blankaartia acuscutellaris on man (p. 62).

Euschöngastia oudemansi on a varanid (p. 63).

Euschöngastia indica on a millipede (p. 64).

Chiggers on secondary (occasional or casual) hosts:—

Eutrombicula wichmanni on rodents and many birds (p. 59).

Siseca rara on rodents and insectivores (p. 60).

Fonsecia celesteae on a skink (p. 73).

Blankaartia acuscutellaris on rats (p. 62).

Heaslipia gateri on rats (p. 63).

Summary

1. Routine examination of a total of 843 reptiles, 721 birds, and a number of scorpions and pill-millipedes during the course of investigations on scrub typhus and enzootic Japanese encephalitis in Malaya has yielded larvae (chiggers) of 15 species of trombiculid mites of which 6 are described as new species.

2. A new genus of reptile-chiggers and two new subgenera are raised as follows:—

Siseca, new genus (= *Trombicula rara* group, p. 41), with 4 species.

Eutrombicula, *Eltonella* new subgenus (p. 32), with 3 species.

Trombicula, *Vercana* new subgenus (= *T. vercа* group, p. 51), with 6 species, including some bird-chiggers.

3. *Eutrombicula* Ewing is restored to generic rank and broadened to include five groups:—

(*a*) Subgenus *Eutrombicula* sensu stricto (p. 31), with over 20 species including *Eutrombicula (Eutrombicula) ahlephara* (Womersley, 1952) and *E. (E.) tovelli* (Womersley, 1952), new combinations, and occurring particularly in the New World and Australasia.

(*b*) New subgenus *Eltonella* (p. 32), with two Malaysian and one Australian species, including *Eutrombicula (Eltonella) fritsi* (Wharton, 1945), new combination.

(*c*) *lawrencei*-group (expanded, including most of the *ilesi*-group of an earlier paper; p. 31), with over 11 species, all African—this group is being described as a new subgenus elsewhere.

(*d*) *ilesi*-group (monotypic, p. 53), from Africa; close to *Eutrombicula* s. str.

(*e*) *fieldi*-group (p. 38), with 2 species from Malaya and Australia, including *Eutrombicula lygosomoides* (Womersley, 1952), new combination; close to the *lawrencei*-group.

4. A new genus, *Siseca*, is raised for the *Trombicula rara* group (p. 41) and the following species placed in it:—

Siseca rara (Walch, 1922), new combination, the type species, from reptiles and occasionally mammals, Malaysia and Australasia.

Siseca lundbladi (Womersley, 1952), new combination, from a skink, New Guinea.

Siseca subrara n.sp., from pill-millipedes, Malaya.

Siseca thori (Womersley, 1952), new combination, from a skink, Queensland.

5. Six new reptile- and arthropod-chiggers from Malaya are described as follows:—

Eutrombicula (Eltonella) eltoni, from scorpions.

Eutrombicula (Eltonella) tweediei, from flying lizards (*Draco*).

Eutrombicula (*fieldi*-group) *fieldi*, from a skink and *Draco*.

Siseca subrara, from pill-millipedes.

Babiangia hooliati, from skinks.

Fonsecia celesteae, from a snake and a skink.

6. Five other true reptile- and bird-chiggers were encountered: *Eutrombicula (Eutrombicula) wichmanni*, *Siseca rara*, *Babiangia parmifera*, *Neoschöngastia gallinarum*, and *N. riversi*. Evidence from other collections suggests that at least three other species or their local representatives should be expected on birds in Malaya, namely *Trombicula (Vercana) vorca*, *Blankaartia acuscutellaris* and *Heaslipia gateri**.

7. Although the vectors of scrub-typhus, *T. (Leptotrombidium) deliensis* and *T. (L.) akamushi*, are essentially mammal chiggers, certain ground birds are known to be locally important hosts. In the Malayan collection, quails in grassland apparently carry several times more *T. akamushi* than field-rats in the same habitat. No evidence was found that the same high degree of infestation occurred with *T. deliensis*, but this might obtain locally.

8. Evidence from both mammal and bird collections suggests that *T. akamushi* occurs much more locally than *T. deliensis*, being practically restricted to the field-rat, *R. argentiventer*, and ground-birds such as quail in open grassland. In these foci, *T. akamushi* occurs in significantly larger numbers than *T. deliensis* does over its whole area of distribution in Selangor. On the other hand, *T. deliensis* is much more widespread than *T. akamushi*, occurring in forest fringe and plantations and involving a much greater variety of mammalian hosts (as well as ground-birds to a much lesser extent): in these conditions any local factors such as fallowing of small-scale clearings which encourage concentrations of rodents will allow the infestation by the vector to build up to levels associated with definite risks of scrub-typhus infection.

9. A list of reptiles, birds, and arthropods examined for chiggers is presented. Details of chigger infestation are included in the list and the whole is summarized.

10. In order to place some of the new species, it has been necessary to make some taxonomic revisions of the heterogeneous genus *Trombicula*. It appears that most true reptile-chiggers accomodated in *Trombicula* are not congeneric with most of the mammal-chiggers, and that they will prove to arrange themselves in groups outside *Trombicula* and around such named groups as *Eutrombicula*, *Blankaartia*, *Fonsecia*, *Babiangia*, and *Siseca*. A step has been taken towards this inevitable revision by summarizing recent taxonomic studies of Oriental and African reptile-chiggers, by characterizing, naming, and comparing several distinct species-groups, and by raising new subgenera and a genus for some of them.

11. *Fonsecia* and *Blankaartia* are regarded as genera. *Heaslipia* is considered to be very close to and derived from the same stem as *Blankaartia*, the two being provisionally grouped as a *Blankaartia* complex.

12. A *Babiangia* complex is recognized, comprising *Babiangia* (revised sensu lato) with three species, *Novotrombicula* with one species, and *Siseca* with four species.

13. *Sauriscus* is confirmed as a distinct genus, apparently derived from the same parent stem as the *lawrencei*-group, and unrelated to *Tecomatlana* and *Trisetica*.

14. Two new species, *Siseca subrara* and *Eutrombicula (Eltonella) eltoni*, are parasitic on pill-millipedes and scorpions respectively. Both belong to groups of true reptile-chiggers.

* See postscript on p. 78: these three have since been found on birds in Selangor.

15. Casual infestation of reptiles and arthropods by stragglers from certain groups of mammal-chiggers included *Trombicula (Leptotrombidium) akamushi* on a skink, *Euschöngastia (Walchiella) audenansi* on a monitor lizard, *Euschöngastia (Laurentella) indica* on a pill-millipede, and, from a collection in Borneo, *T. (L.) deliensis* on a tipulid fly. The recording of such infestations from exceptional or from secondary casual hosts is discussed, and the importance of not confusing straggling with fairly regular infestation is stressed. The biological value of taxonomic contributions would be greatly increased by publishing records of hosts examined but not found infested, as well as those found infested.

16. Not enough is yet known about the postlarval stages to allow further taxonomic revisions. Several important groups are completely unknown except as larvae. Single eyes are present in postlarval stages only of certain groups of reptile-chiggers (*Eutrombicula* s.s., *Eltonella*, *Blankaartia*, *Heaslipia*), and *Ipotrombicula* of which the host is unknown. Double eyes are present in postlarval stages of *Hannemania*, the larvae of which are endodermal in amphibians. Single eyes are present in postlarval stages. The significance of this demands further enquiry, but it would appear that the presence of eyes in nymphs and adults is a primitive character.

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Postscript.—Since this paper went to press, (a) *Trombicula vorca* or a form extremely close to it has been found in some numbers on two birds, *Otus bakkamoena lempiji* (213, Collared Scops Owl) and *Halcyon c. concreta* (262, Chestnutcollared Kingfisher) from Bk. Lagong F.R., and nymphs have been reared; (*b*) *Blankaartia acuscutellaris* has been found, but usually in small numbers, on two species of *Centropus* (Crow Pheasant, frequenting grassy and swampy land), *Ixobrychus cinnamomeus* (27, Schrenck's Bittern), 2 *Capella stenura* (132, Pintail Snipe), *Amaurornis phoenicurus chinensis* (100a, Whitebreasted Water-Hen), which are all associated with water, and also a *Drymophila p. pyrroptera* (512, Chestnut-winged Flycatcher); (*c*) *Heaslipia gateri* has been found together with *B. acuscutellaris* on a Schrenck's Bittern from a grassy swamp in Selangor; and (*d*) Nymphs of *E. tweediei* have been reared and found to be *without* eyes though otherwise generally similar to the nymphs of *E. eltoni*: this is extremely interesting in view of the apparent absence of eyes in the nymphs of certain species which in the larva are typical *Eutrombicula* s. str. (see Audy, 1954: 146), and it suggests that a close comparison should be made of postlarval stages of *Blankaartia* and *Neotrombicula* which appear to differ more markedly in the postlarval than in the larval stage, particularly in the absence of eyes in *Neotrombicula* nymphs and adults.

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